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REPORT OF THE IRRIGATION AND POWER TEAM

ON

NAGARJUNASAGAR PROJECT

(ANDHRA PRADESH)

COMMITTEE ON PLAN PROJECTS
NEW DELHI
JULY 1960

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LETTER OF TRANSMITTAL

No. COPP/I&P/7/59
COMMITTEE ON PLAN PROJECTS
YOJANA BHAVAN
Parliament Street,
NEW DELHI.
23rd July, 1960.

Dear Shri Pantji,

I have pleasure in forwarding to you the Report of the Irrigation & Power Team on the Nagarjunasagar Project. The study of the Project was initiated under the able Leadership of my predecessor, Shri N. V. Gadgil, who relinquished the Leadership on 26th September, 1959.

2. The Team prepared their preliminary Draft Report after visiting the Project site a number of times and discussing in detail the various issues with the Project Authorities. The same was forwarded to the Government of Andhra Pradesh on 2nd February and discussed with them on 25th and 26th March, 1960. The Report has been finalised in the light of decisions arrived at at that meeting.

3. Among the recommendations made by the Team, the following are the more important :—

(*i*) Build the Dam to its final height in the first phase with sill of spillway gates lowered to R.L. 546 and defer installation of the spillway gates to the final phase.

This will enable storage of water to F.R.L. 546 and thereby ensure an annual irrigation of 18 lakh acres of first crop and 1.25 lakh acres of second crop as against an annual irrigation of not more than two-thirds of 18 lakhs of first crop and no second crop, which is all that can be secured by building the Dam to F.R.L. 525 as proposed in the project for the first phase.

The additional expenditure involved will be Rs. 2.5 crores.

(*ii*) Increase, in the interest of safety, the spillway capacity by adding three bays to the 24 bays of 50 feet

each, making 27 bays in all and lower the sill of all the gates from R.L. 550 to R.L. 546, so that the gates will now be 44 feet instead of 40 feet in height.

If the results of certain suggested studies indicate the necessity for further increase in spillway capacity, this should be secured in the form of a saddle spillway on the left bank.

(*iii*) Provide for developing in the first phase 100 M.W. of power.

The additional expenditure involved will be Rs. 4 crores and the additional revenue earned each year will be Rs. 70 lakhs, which will improve the financial return of the project.

(*iv*) Lower the full supply level of the Left Bank Canal by 10 feet (by suitably widening the intake channel in the first phase and making provision for constructing a second tunnel in the second phase), thus enabling the reservoir storage between R.L. 520 and R.L. 510 to be utilised, thereby increasing the second crop irrigation by 42,000 acres per annum on the average.

(*v*) Accept the proposal of the Project Authorities to design the Left Bank Canal for an ultimate (final stage) discharge of 15,000 cusecs and construct during the first phase all masonry works for this discharge of 15,000 cusecs but build the canal only for the first phase discharge of 11,000 cusecs.

This will provide additional annual irrigation of 3.5 lakhs below the point where the canal proposed for 11,000 cusecs will end. This additional irrigation will be feasible on the basis of 75 per cent dependability.

(*vi*) Provide water for early sowing of cotton and for the irrigation of upper lands adjoining the distributaries (which under the project have been excluded) in addition and in preference to the lower valley lands and irrigate these later by lift of the sub-soil water thus eliminating the possibility of water-logging.

(*vii*) Plan all projects on the Krishna on the basis of 75 per cent dependability.

(*viii*) Integrate operation of Nagarjunasagar Reservoir with the Srisailam Reservoir when constructed. This will result in an increase in annual irrigation of 3 lakhs of acres of second crop and power generation at Srisailam from 260 M.W. to 377 M.W. at 60 per cent load factor.

(*ix*) Arrange early adjustment in the 1951 Award on the allocation of Krishna waters consequent on the re-organisation of States which has taken place since.

(*x*) Prepare without delay a revised detailed project estimate incorporating all changes introduced by the Project Authorities to-date and those suggested by the Team.

4. I take this opportunity of thanking you for the constant interest you have taken in the Team's study and the guidance you have given me from time to time. I would also place on record the help and guidance which the Members of the Consultative Committee have given to the Team throughout.

Yours sincerely,

A. N. KHOSLA.

Shri Govind Ballabh Pant,
Home Minister,
Government of India,
NEW DELHI.

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*Being published separately.

MAPS AND CHARTS

PREFACE

The Committee on Plan Projects set up by the National Development Council decided in May, 1958 that Koyna and Nagarjunasagar multi-purpose Projects should be studied in accordance with the Terms of Reference, with a view to securing economy and efficiency in the utilization of financial and other scarce resources. The Team for Nagarjunasagar Project consisted of :—

Shri N. V. Gadgil — Leader

Shri Balwant Singh Nag,
formerly Member, High Level
Committee on Floods, C.W. & P.C.

Shri M. P. Mathrani, — Members
Chief Engineer (Retd.), Bihar.

* Shri Lal Singh
Director of Agriculture (Retd.), Punjab.

Shri N. V. Gadgil relinquished the Leadership of the Team towards the end of September, 1959. Later Dr. A. N. Khosla joined as Leader of the Team.

The Team was assisted by a Consultative Committee, consisting of the following eminent Engineers :

Dr. A. N. Khosla,
Vice-Chancellor, Roorkee University.

Shri N. N. Iyengar,
Electrical Adviser,
Hindustan Steel (P) Ltd.

Shri M. S. Thirumale Iengar,
Chief Engineer, Hirakud.

Shri A. C. Mitra,
Chief Engineer, Irrigation & Rihand Project (U.P.).

** Shri S. D. Khungar,
formerly General Manager,
Bhakra Dam Project.

Shri D. S. Borker, Secretary to the Consultative Committee also worked as Secretary to the Irrigation & Power Team.

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*Appointed in September, 1958, as additional Member to study agricultural aspects.

**Joined in November, 1959.

The Terms of Reference which were communicated by the COPP in their Memorandum No. COPP/4(14)/58, dated the 13th May, 1958 required that the Team should make a study of the various aspects of the two Projects and of the following ones in particular :—

(1) The aspects of the Project having a bearing on economy and efficiency with special reference to :

(*a*) Utilisation of trained personnel and materials;

(*b*) Utilisation of machinery and equipment;

(*c*) Construction Plan lay-out;

(*d*) Adequacy of original estimates and designs as evidenced from actual construction of the Project;

(*e*) Phasing of construction with a view to studying whether :

(*i*) timely utilisation of benefits accruing from the Project has been ensured;

(*ii*) it is possible to accelerate accrual of benefits; and

(*iii*) benefits could be increased by rephasing the Project at this stage;

(*f*) Sufficiency of investigations conducted at the Planning stage with a view to the formulation of project estimates; and

(*g*) The effect of the above study on the financial results of the Project, if any.

(2) Generally to assess the progress made in construction, the reasons for shortfall, if any, and to suggest measures for improvements in the future;

(3) To examine the possibility of decreasing dependence upon imported materials and equipment required for the Project;

(4) To examine whether adequate steps have been taken by the authorities concerned for fixing and realising the contemplated water rates, betterment fees and/or any other rates, cesses or taxes; and

(5) To report on any other aspect that the Team may like, in order to ensure economy and efficiency in the construction of the Project.

The Members of the Team paid a number of visits to the Nagarjunasagar Project and had detailed discussions with the Chief Engineers for Canals and Dam and other officials connected with the Project. The Leader, along with the Members of the Consultative Committee, visited the Project site from 24th to 26th October, 1958. Team gave its interim recommendations on the 9th November, 1959 which were discussed by the Consultative Committee at the meeting held at Roorkee on the same day. Extracts of the Team's recommendations calling for immediate modifications in the design of spillway and Left Bank Canals were forwarded on the 8th January, 1960 by the Leader to the Central Water and Power Commission and the Government of Andhra Pradesh, to enable them to take timely action. The Team discussed in detail the Draft Report at the Consultative Committee Meeting held on 18th January, 1960 and necessary modifications were made therein. A copy of the Draft Report was forwarded to the Government of Andhra Pradesh and was subsequently discussed with them on 25th and 26th March, 1960. A copy of the Draft Report as finalised in light of decisions taken at that meeting was forwarded to the Chairman, Central Water and Power Commission for remarks. The Team is glad to note that the Central Water and Power Commission are in general agreement with its recommendations.

The Team would like to place on record their gratitude to the Government of Andhra Pradesh for the facilities extended for the conduct of investigations and the spirit of accommodation shown by the Chief Engineers, Sarvashri M. Jaffer Ali and G.A. Narasimha Rao and other concerned officials.

CHAPTER I

SCOPE OF THE PROJECT

1.1. The present Project is based on the Joint Report for Nandikonda Project prepared by Andhra and Hyderabad States in 1954. The estimated cost of the Project was Rs. 122 crores which was at that time to be shared by the two States. The cost of the three units and the irrigation benefits as shown in that Project are given below :—

Cost	*Rs. Crores*
Dam	34·7
Right Bank Canal	61·1
Left Bank Canal	26·2
Total ..	122·0

Irrigation benefits	*Lakh Acres*
Delta	3·25
Right Bank Canal	18·58
Left Bank Canal	10·00
Total ..	31·83

1.2. It was indicated in the Joint Report that the Project was capable of being executed in two phases. The first phase provides :—

1. Dam upto .. .. 525 F.R.L.
2. Right Bank Canal (lined upto mile 62) .. .. 140 miles
3. Left Bank Canal (lined upto mile 40) .. .. 108 miles

The cost of the three units in the first phase is shown as :—

	Rs. Crores
Dam	32·1
Right Bank Canal	31·6
Left Bank Canal	21·8
Total ..	85·5

The irrigation benefits as shown at page 82 of the 1954 Project are :—

First Crop	*Lakh Acres*
Delta	1·5
Right Bank Canal	9·7
Left Bank Canal	6·7
Total ..	17·9

Second Crop	*Lakh Acres*
Left Bank Canal	1·2
Grand Total ..	19·1

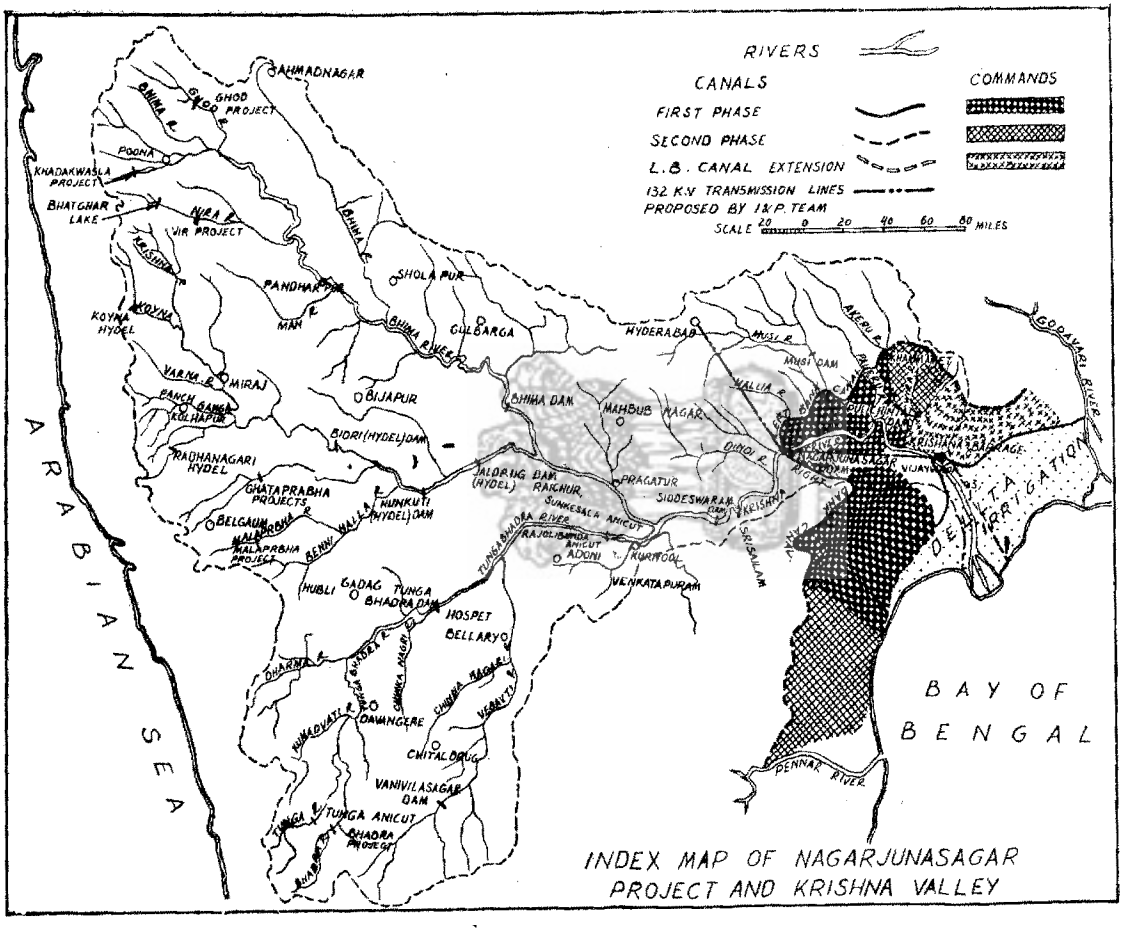
In working tables, however, no provision of water is made for second crop. The irrigation benefits as shown at page 89 of the 1954 Project are :—

	Lakh Acres
Krishna Delta First Crop	1·5
Right Bank and Left Bank Canals	18·5
Total ..	20·0

1.3. Before the Project was accepted by the Government of India, the possibilities of reducing the cost of the first phase were looked into by the Chief Engineers of Andhra and Hyderabad States. The cost of the first phase was reduced to Rs. 75.08 crores by deleting lining etc. and on this basis the Planning Commission agreed to include the same in the First Five Year Plan.

1.4. In October 1956, the first phase estimate was prepared by Andhra Government and the estimated cost of the three units and their irrigation benefits as shown therein, are detailed below :—

Irrigation benefits	*Rs. Crores*
Dam	33·84
Right Bank Canal	29·33
Left Bank Canal	23·40
Total ..	86·57



INDEX MAP OF NAGARJUNASAGAR PROJECT AND KRISHNA VALLEY

Irrigation benefits—(contd.)	*Lakh Acres*
Delta	
First crop	1·50
Second crop	1·50
Right Bank Canal	
First crop	9·70
Left Bank Canal	
First crop	6·70
Second crop	1·20
Total ..	20·60

1.5. These figures have since been revised due to increase in the cost of the cement, steel etc. and the present estimated cost of the three units is as under :—

	Rs. Crores
Dam	36·38
Right Bank Canal	30·78
Left Bank Canal	23·96
Total ..	91·12

This estimate had been sanctioned by the Nagarjunasagar Control Board in their XX meeting held on 30th December, 1958. No sanction has yet been given to any estimate by the Government of India.

1.6. The salient features of the Project as shown in the 1956 estimate for the first and the final phase are given in Appendix I. Some of the features, however, have since been changed during actual execution.

CHAPTER II

AVAILABILITY OF WATER

2.1.1. A Conference was held in the Planning Commission, New Delhi on the 27th and 28th July, 1951 with representatives of Bombay, Madras, Hyderabad, Madhya Pradesh and Mysore Governments to discuss the utilization of supplies in the Krishna and Godavari river-basins so that an assessment could be made of the relative merits of the projects proposed for inclusion in the second part of the Five Year Plan.

2.1.2. With a view to determining the dependable supplies in the river Krishna a note was prepared by Central Water and Power Commission on the basis of the discharge observations of the river Krishna at Vijayawada site for the years 1895 to 1945, *i.e.* for fifty-one years. On the basis of this data it was computed that a run-off of 1450 T.M.C. Feet* was available in forty-four years out of fifty-one. This was exclusive of the existing utilization of 265 T.M.C. Feet. On this basis the total dependable supply in the Krishna river basin was taken as 1715 T.M.C. Feet. While allocating these supplies to the various States this figure was rounded to 1745 T.M.C. Feet. The existing utilisations plus flows required for projects under construction at that time were 745 T.M.C. Feet. The remaining 1,000 T.M.C. Feet were allocated to various States for new projects. The balance flows in excess of 1,000 T.M.C. Feet were also allocated to the various States. The allocations as fixed by the Planning Commission were as under :—

States	For net flows upto 1000 T.M.C. Feet		For balance net flows in excess of 1000 T. M. C. Feet.
Bombay	240	24%	30%
Hyderabad	280	28%	30%
Mysore	10	1%	1%
Madras	470	47%	39%

2.1.3. Since 1951 there has been reorganisation of States and this would necessitate an adjustment in the allocation of Krishna waters to various States concerned on the basis of the territorial changes that have taken place. This is under examination in Central Water and Power Commission. As all the concerned States are considering various new schemes for the utilization of Krishna waters, the Team

*T.M.C. Feet=Thousand Million Cubic Feet.

suggests that this question may be settled at an early date. The Team had made a similar recommendation in its Report* on Koyna Project.

2.2.1. The question of availability of water for Nagarjunasagar Project from the dependable yield of 1745 T.M.C. Feet has not been considered in the 1954 or 1956 Project Reports. In the 1954 Project four working tables are given based on the inflows gauged at Vijayawada anicut during 1929-30. The yield for the year 1929-30 for which tables have been prepared is 1921 T.M.C. Feet. This is in excess of the dependable yield by twelve per cent and gives a dependability of seventy-six per cent against eighty-six per cent on which the allocations are based.

2.2.2. On the basis of the dependable yield of 1745 T.M.C. Feet, there is just sufficient water for the irrigation stipulated in the project from Nagarjunasagar (Appendix II). The construction on the Dam at Srisailam, even if no water is withdrawn from it for irrigation, will result in a deficit of about 33 T.M.C. Feet at Nagarjunasagar due to evaporation losses at Srisailam. The State is also proposing to extend the Left Bank Canal to provide water for additional 3.5 lakh acres of irrigation. There is also a proposal for constructing Krishna Pennar Canal for irrigation in Rayalaseema area.

2.2.3. It is, therefore, for consideration whether the scope of projects for assured irrigation should be extended beyond the dependable yield adopted in the 1951 Award. This question has been discussd with Central Water and Power Commission and it has been suggested by them that many of the current projects under sanction are planned on seventy-five per cent to eighty per cent dependability and this should be adopted for the Krishna basin. The Project Authorities have expressed similar views during discussions. This question has also been discussed with the Consultative Committee and they have expressed that for the assured irrigation projects on Krishna river, a dependability of seventy-five per cent may be adopted, and that the same percentage be adopted in respect of projects of all States on the Krishna river. The Team has adopted this basis in considering the availability of water for the extended scope of the Nagarjunasagar Project and its integration with Srisailam Project.

2.2.4. The Team suggests that the basis for the allocation of Krishna waters to various States should remain the same as in the 1951 Award. The allocations should be modified to the extent indicated by territorial changes as a result of reorganisation of States. It is stipulated in the Award that the position should be reviewed after a period of twenty-five years and this should stand.

2.2.5. On the basis of seventy-five per cent dependability the share of Andhra State at Srisailam, after allowing for the new projects upstream, works out to 614 T.M.C. Feet (Appendix II). This figure of yield at Srisailam has been worked out by adopting the same

*Please refer page 19 of the Report of the Irrigation and Power Team on Koyna Project (Bombay State)—February 1959.

basis as in the Nagarjunasagar Project Report for different reaches of the river Krishna and allowing for upstream projects as worked out by the Central Water and Power Commission. The demands for the Nagarjunasagar Project and two new projects under consideration, namely Left Bank Canal Extension and Krishna-Pennar Canal as given by the Project Authorities and the Central Water and Power Commission are shown below :—

	T.M.C. Feet.
(1) *Nagarjunasagar schemes as per 1954 Project*	
(*i*) Right Bank Canal	222
(*ii*) Left Bank Canal	186
(*iii*) Delta irrigation from Nagarjunasagar reservoir	111
(*iv*) Evaporation losses at Nagarjunasagar	16
(*v*) Firming up of power	20
Total ..	555
(2) *Left Bank Canal*	
Extension schemes for 3·5 lakh acres	42
(3) *Srisailam Project*	
(*i*) Krishna-Pennar Canals	41
(*ii*) Evaporation losses at Srisailam	33
Total ..	74

The yield below Srisailam will be 614—74= 540 T.M.C. Feet. The intermediate yield between Srisailam and Nagarjunasagar on the Project basis exclusive of existing utilisation, works out to 40 T.M.C. Feet. The total yield at Nagarjunasagar will thus amount to 580 T.M.C. Feet. The total demand at Nagarjunasagar under item (1) and (2) is 597 T.M.C. Feet. Thus there will be a shortage of about 17 T.M.C. Feet for the Left Bank Canal Extension. This will require adjustment.

2.2.6. It may be further mentioned that 1.5 lakh acres of first crop irrigation for the Delta provided in the phase estimate has already been developed with minor irrigation funds from the Krishna Barrage. It is now proposed to transfer 1.5 lakh acres to the accepted ayacut of Nagarjunasagar Canals (Appendix III). This extra area, if provided on Nagarjunasagar Canals, will require about 27 T.M.C. Feet more of water if it is all wet, or 18 T.M.C. Feet if it is one-third wet and two-thirds dry. As explained above there is no extra water available even on the basis of seventy-five per cent dependability, if requirements of Left Bank Canal Extension Scheme and Srisailam Project are to be provided for. It would, therefore, not be advisable to extend the scope of assured irrigation on Nagarjunasagar Canal system further at this stage and if this is done this point should be kept in mind in considering the availability of water for Krishna-Pennar Canals.

CHAPTER III

FEASIBILITY OF FIRST PHASE PROJECT

3.1.1. The first phase of the 1954 Project provides for irrigation of 18.5 lakh acres of first crop from Nagarjunasagar Canals and 1.5 lakh acres of additional first crop in the Delta, *i.e.*, 20 lakh acres in all. In 1954 Project the working table for the first phase has been prepared on this basis. However, the First Phase 1956 estimate provides for irrigation of 17.9 lakh acres of first crop (16.4 lakh acres on Nagarjunasagar Canals and 1.5 lakh acres in the Delta) and 2.7 lakh acres of second crop (1.5 lakh acres in the Delta and 1.2 lakh acres on the Left Bank Canal), *i.e.*, 20.6 lakh acres in all. In addition, credit has been taken in the water cess revenue for 7.65 lakh acres of catch crops on the Left Bank Canal in the financial forecast. It appears that no working tables were prepared to see if it would be possible to do the second crop irrigation of 2.7 lakh acres with F.R.L. 525 as proposed in the First Phase Project, when the area of irrigation provided in the 1954 Project was changed.

3.1.2. While preparing the working table for the first phase in the 1954 Project, it has been assumed that no new projects will be undertaken in the upper States during the operation of that phase. This was an unrealistic assumption. There are a number of new projects already under construction in Krishna river basin in the upper States. The lowest reservoir level is shown as R.L. 486 in Table No. III of 1954 Project report, which is below the sill level of the head sluices of the two Nagarjunasagar Canals. This should have indicated that F.R.L. 525 for the Dam would not be adequate for the first phase.

3.2.1. With a view to ascertaining the feasibility of the first phase irrigation with F.R.L. 525, the Team has prepared a working table (Table No. 1) for the first phase irrigation as provided in 1956 Project for the year 1937-38, which is a year of seventy-five per cent dependability. This working table has been based on the assumption that the upper States will be utilising half of their allocations for new projects. This roughly tallies with the utilisations of the projects, which have already been undertaken (Statement II). On this basis it is seen that even the first crop irrigation provided in the first phase estimate cannot be done with F.R.L. 525. The lowest level goes down to R.L. 495 by the end of June, while the working level required for the two canals in the beginning of July is about R.L. 504. For the full irrigation provided in the 1956 Project, the lake level goes up to R.L. 560, which is much above the designed sill level of the spillway gates.

3.2.2. This question, as to how second crop irrigation would be done, was referred to the Project Authorities in June, 1959 and has also been discussed with them. No revised working tables with F.R.L.

525 have been received from the Project Authorities so far though requested for a number of times. During discussions it was expressed by them that there will be difficulty in doing the second crop irrigation and that second crop is a gift, which may be reduced or abandoned. This question was referred to the Central Water and Power Commission also and they have stated that for irrigation two million acres of the sanctioned project, the Nagarjunasagar Dam has to be constructed for F.R.L. 540, but no working table has been supplied by them for it.

3.2.3. The first phase Dam is now expected to be completed by the Project Authorities in 1965-66 and it is not unlikely that some more projects will be started in Krishna basin upstream of Nagarjunasagar by that time, which will make the first crop irrigation even more difficult.

3.3.1. In view of the fact that these difficulties were not visualised at the time of the commencement of the Project, there would be two alternatives. One alternative would be to complete the Dam as proposed up to F.R.L. 525 and curtail the length of the canals to do about two-thirds of the first crop irrigation which only can be done safely (Working Table No. I-A). The second alternative would be to complete the masonry of the Dam to the final height (F.R.L. 590) and leave the installation of the gates to be done in the second phase. Under the recommendations on "Spillway Capacity" in Chapter V, the Team has suggested that the sill level of the spillway gates may be kept at R.L. 546. This will enable the F.R.L. in the first phase to be kept at R.L. 546. The Team has prepared Working Table No. I-B to determine the scope of irrigation that can be done with F.R.L. 546. It is seen that the first crop irrigation provided in 1956 Project can be done fully and in addition about 1.25 lakh acres of second crop can be done in the Delta and also about 40 M.W of firm continuous power can be generated.

3.3.2. The total masonry and concrete to be done in the first phase with F.R.L. 525 is 171 M.C. Feet and that for the final phase with F.R.L. 590, 191 M.C. Feet which is about 20 M.C. Feet more than first phase masonry. This is just one season's work. If the construction of the remaining masonry is done after a number of years after the completion of the first phase, it would involve purchasing fresh machinery or bringing back the old machinery, if it is still available, to do the remaining masonry of 20 M.C. Feet. The masonry will cost very much more, than if it is done in continuation of the first phase programme. The extra work in completion of the Dam to final height will cost about Rs. 2.5 crores.

3.3.3. Out of the two alternatives the second one appears preferable. The additional funds for raising the masonry above F.R.L. 525 to F.R.L. 546 will be required in the first year of the Fourth Five-Year Plan.

Note for Working Table No. 1, *regarding Inflows available at Nagarjunasagar in a year like* 1937-38 (75% *dependable*) *when half the new upper projects materialise.*

		T.M.C. Feet
1.	Gauged inflows at Vijayawada for 1937-38 (Appendix II-B) ..	1706
2.	Gauged inflows at Vijayawada in 86% dependability year which forms the basis of 1951 Award	1,480
3.	Extra flows above basic flows	226
4.	Flows (basic) available in 86% year at Nagarjunasagar (as given by C.W. & P.C.—(Appendix II-A).	562
5.	50% basic allocations of upper projects which amount to 474 T.M.C. Feet, (Appendix II-A). $\frac{1}{2} \times 474 =$	237
6.	Flows from surplus flows reaching Nagarjunasagar when half the upper projects materialise :	
	(*a*) Half of upper States share $= \frac{1}{2} \times 46 \cdot 5 =$	23·25%
	(*b*) *Andhra's share	53·50%
	Total	76·75%
	(*c*) Less flows below Nagarjunasagar	12·75%
	(*d*) Net excess flows upto Nagarjunasagar available for use in first phase.	64·00%
	(*e*) Excess flows at Nagarjunasagar $= 226 \times 0 \cdot 64 =$	144
7.	Total inflows at Nagarjunasagar = (4)+(5)+(6) = ...	943

NOTE. *The share of Andhra State as reorganised in the surplus flows of river Krishna over and above basic flows of 1480 T.M. C. Ft. is 53·50% as worked out by C.W. & P.C. (39% of old Madras State and 14·5% of old Hyderabad State).

Working Table 1

First Phase Irrigation as provided in 1956 *Project on the basis of* 1937-38 (75% *dependability*) *assuming that only* 50% *utilisations are made on new projects upstream of Nagarjunasagar.*

Period		Gauged Inflows at Vijaya-wada (a)	Inflows at N.S. (b)	Demands at N.S.		I. Without Second crop			II. With Second crop		
				Only first crop	First crop + 2nd crop	Lake contents	Surplus	Lake levels	Lake contents	Surplus	Lake levels
1		2	3	4(i)	4(ii)	5(i)	6(i)	7(i)	5(ii)	6(ii)	7(ii)
May	II	1·7	0·9	5·20	5·20	204·10	—	507·80	223·9 219·6	—	516·1
June	I	1·3	0·7	8·40	8·40	196·40	—	502·60	211·9	—	512·0
	II	16·2	8·9	24·30	24·30	181·00	—	495·00	196·5	—	504·0
July	I	153·1	84·7	28·30	28·30	237·40	—	525·40	252·9	—	532·5
	II	451·5	248·3	22·80	22·80	238·00	224·9	525·00	317·4	161·0	560·2
Aug.	I	315·1	174·0	29·00	29·00	238·00	145·0	525·00	317·4	145·0	560·2
	II	138·6	76·6	27·20	27·20	238·00	49·4	525·00	317·4	49·4	560·2
Sep.	I	47·3	26·1	28·80	28·80	235·30	—	524·30	314·7	—	559·3
	II	183·0	101·3	24·00	24·00	238·00	74·6	525·00	317·4	74·6	560·2
Oct.	I	268·9	148·5	19·50	19·50	238·00	129·0	525·00	317·4	129·0	560·2
	II	60·7	33·5	29·20	29·20	238·00	4·3	525·00	317·4	4·3	560·2
Nov.	I	35·1	19·4	29·40	29·40	228·00	—	520·50	307·4	—	556·4
	II	11·0	6·1	25·40	25·40	208·70	—	510·20	288·1	—	548·8
Dec.	I	5·6	4·8	7·00	7·00	206·50	—	509·20	285·9	—	547·4
	II	3·8	2·1	0·50	5·30	208·10	—	510·10	282·7	—	546·0

Jan.	I	3·0	1·7	0·50	4·20	209·30	—	510·50	280·2	—	544·8
	II	2·0	1·1	0·50	6·00	209·90	—	511·00	275·3	—	542·6
Feb.	I	1·3	0·7	0·50	8·90	210·10	—	511·10	267·1	—	539·0
	II	0·7	0·4	0·50	6·80	210·00	—	511·00	260·7	—	536·2
Mar.	I	0·4	0·2	0·90	8·20	209·30	—	510·50	252·7	—	532·7
	II	0·2	0·1	0·80	7·80	208·60	—	510·15	245·0	—	529·0
Apr.	I	2·2	1·2	1·10	9·00	208·70	—	510·20	237·2	—	525·2
	II	2·1	1·2	1·00	8·00	208·90	—	510·25	230·4	—	522·0
May	I	0·9	0·5	1·00	7·00	208·40	—	510·00	223·9	—	518·3
	Total	17,05·7	943·0	315·80	379·70		627·2			563·3	

Explanations :

(*a*) From figures supplied by Dir. (H. & S.) C.W. & P.C. (Appendix II-B).

(*b*) As per note preceding the Working Table.

(*c*) As per Statement I prepared from Demands in C.W. & P.C. 's Working Tables accompanying their Memorandum TM—1000—NS—4 on Power Penstocks at Nagarjunasagar.

STATEMENT I

Demands at Nagarjunasagar first phase

Month and Period		Demand without Second crop					Demand with Second crop also		
		Net demand for delta irrigation (a)	Demand for R.B. Canal (b)	Demand for L.B. Canal (c)	Evaporation losses (d)	Total of cols. 2, 3, 4 and 5	Demand for delta irrigation 2nd crop (e)	Demand for L.B. Canal 2nd crop (f)	Total of cols. 2, 3, 4, 5 7 and 8
		MCFt.	MCFt.	MCFt.	MCFt.	TMCFt.	MCFt.	MCFt.	TMCFt.
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
May	II	2,370	793	1,306	735	5·2	—	—	5·2
June	I	4,991	1,081	1,560	718	8·4	—	—	8·4
	II	17,054	2,643	3,875	735	24·3	—	—	24·3
July	I	7,113	10,265	10,378	529	28·3	—	—	28·3
	II	—	10,920	11,425	419	22·8	—	—	22·8
Aug.	I	4,855	11,615	11,760	740	29·0	—	—	29·0
	II	1,874	12,947	11,595	766	27·2	—	—	27·2
Sep.	I	7,236	10,125	10,669	766	28·8	—	—	28·8
	II	2,759	10,189	10,263	766	24·0	—	—	24·0
Oct.	I	—	8,666	10,062	764	19·5	—	—	19·5
	II	8,500	10,768	9,197	754	29·2	—	—	29·2
Nov	I	11,747	8,621	8,515	486	29·4	—	—	29·4
	II	9,596	9,498	5,870	463	25·4	—	—	25·4

Dec.	I	..	..	..	..	..	—	1,881	4,602	447	7·0	—	—	7·0
	II	..	..	..	..	..	—	—	—	433	0·5	—	4,816	5·3
Jan.	I	..	..	..	..	..	—	—	—	426	0·5	—	3,800	4·2
	II	..	..	..	..	..	—	—	—	415	0·5	—	5,530	6·0
Feb.	I	..	..	..	..	..	—	—	—	401	0·5	3,302	5,190	8·9
	II	..	..	..	..	..	—	—	—	388	0·5	2,884	3,480	6·8
Mar.	I	..	..	..	..	..	—	—	—	842	0·9	3,334	4,010	8·2
	II	..	..	..	..	..	—	—	—	828	0·8	2,622	4,290	7·8
Apr.	I	..	..	..	..	..	—	—	—	1,071	1·1	3,902	4,010	9·0
	II	..	..	..	..	..	—	—	—	1,040	1·0	3,896	3,060	8·0
May	I	..	..	..	..	..	—	—	—	1,008	1·0	3,367	2,620	7·0
											315·8			379·7

Explanations :

(*a*) Col. No. (8) of W.T.I. accompanying C.W & P.C.'s Memo TM-1000-NS-4 on Power Penstocks for Nagarjunasagar excepting demands for Second crop.

(*b*) Col. No. (9) of W.T.I. accompanying C.W. & P.C.'s Memo TM-1000-NS-4 on Power Penstocks for Nagarjunasagar excepting demands for Second crop.

(*c*) Col. No. (10) of W.T.I. accompanying C.W. & P.C.'s Memo TM-1000-NS-4 on Power Penstocks for Nagarjunasagar excepting demands for Second crop.

(*d*) Col. No. (13) of W.T.I. accompanying C.W. & P.C.'s Memo TM-1000-NS-4 on Power Penstocks for Nagarjunasagar.

(*e*) Only Second crop demand from Col. (8) of W.T.I. accompanying C.W. & P.C.'s Memo TM-1000-NS-4 on Power Penstocks for Nagarjunasagar.

(*f*) Only Second crop demand from Col. (10) of W.T.I. accompanying C.W. & P.C.'s Memo TM-1000-NS-4 on Power Penstocks for Nagarjunasagar.

WORKING TABLE I-A

Nagarjunasagar with F. R. L. 525 for first phase and two-thirds of projected irrigation demand for first crop on Left Bank Canal and Right Bank Canal and without any second crop either at delta or Left Bank Canal.

Period		Gauged inflows at Vijaya-wada (a)	Inflows at N.S. (b) TMCFt.	Net demand for delta irriga- (c) MCFt.	2/3 demand for R.B. Canal (d) MCFt.	2/3 demand for L.B. Canal (e) MCFt.	Evapo-ration losses (f) MCFt.	Total demands Col. 3+4+5 +6 TMCFt.	Lake contents TMCFt.	Surplus	Lake levels
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
									221·0		517·0
May	II	1·7	0·9	2,370	528	870	735	4·5	217·4	—	515·0
June	I	1·3	0·7	4,991	720	1,040	718	7·5	210·6	—	511·0
	II	16·2	8·9	17,054	1,770	2,590	735	22·2	197·4	—	504·0
July	I	153·1	84·7	7,113	6,840	6,940	529	21·4	237·0	23·6	525·0
	II	451·5	248·3	—	7,270	7,650	419	15·3	237·0	233·0	525·0
Aug.	I	315·1	174·0	4,855	7,730	7,850	740	21·2	237·0	152·8	525·0
	II	138·6	76·6	1,874	8,650	7,750	766	19·0	237·0	57·6	525·0
Sep.	I	47·3	26·1	7,236	6,750	7,130	766	21·9	237·0	4·2	525·0
	II	183·0	101·3	2,759	6,800	6,850	766	17·2	237·0	84·1	525·0
Oct.	I	268·9	148·5	—	5,800	6,700	764	13·3	237·0	135·2	525·0
	II	60·7	33·5	8,500	7,170	6,130	754	22·6	237·0	10·9	525·0
Nov.	I	35·1	19·4	11,747	5,760	5,670	486	23·7	232·7	—	523·0
	II	11·0	6·1	9,596	6,350	3,920	463	20·3	218·5	—	515·0
Dec.	I	5·6	4·8	—	1,260	3,080	447	4·8	218·5	—	515·0
	II	3·8	2·1	—	—	—	433	0·4	220·2	—	516·5

Jan.	I ..	..	3·0	1·7	—	—	—	426	0·4	221·5	—	517·0
	II ..	..	2·0	1·1	—	—	—	415	0·4	222·2	—	517·5
Feb.	I ..	..	1·3	0·7	—	—	—	401	0·4	222·5	—	518·0
	II ..	..	0·7	0·4	—	—	—	388	0·4	222·5	—	518·0
Mar.	I ..	..	0·4	0·2	—	—	—	842	0·8	221·9	—	517·0
	II ..	..	0·2	0·1	—	—	—	828	0·8	221·2	—	517·0
Apr.	I ..	..	2·2	1·2	—	—	—	1,071	1·1	221·3	—	517·0
	II ..	..	2·1	1·2	—	—	—	1,040	1·0	221·5	—	517·0
May	I ..	..	0·9	0·5	—	—	—	1,008	1·0	221·0	—	517·0
		Total :	1,705·7	943·0	78,095	73,398	74,170	15,940	241·6		701·4	

Explanations :

(*a*) From figures supplied by Dir. (H. & S.), C.W. & P.C. (Appendix II-B).

(*b*) As per note attached to Working Table I.

(*c*) Col. No. (8) of Working Table I accompanying C.W. & P.C's Memo TM-1000-NS-4 on Power Penstocks for Nagarjunasagar excepting demands for second crop.

(*d*) 2/3 of Projected irrigation demand of Col. No. (9) of Working Table I accompanying C.W. & P.C.'s Memo TM-1000-NS-4 on Power Penstocks for Nagarjunasagar excepting demands for second crop.

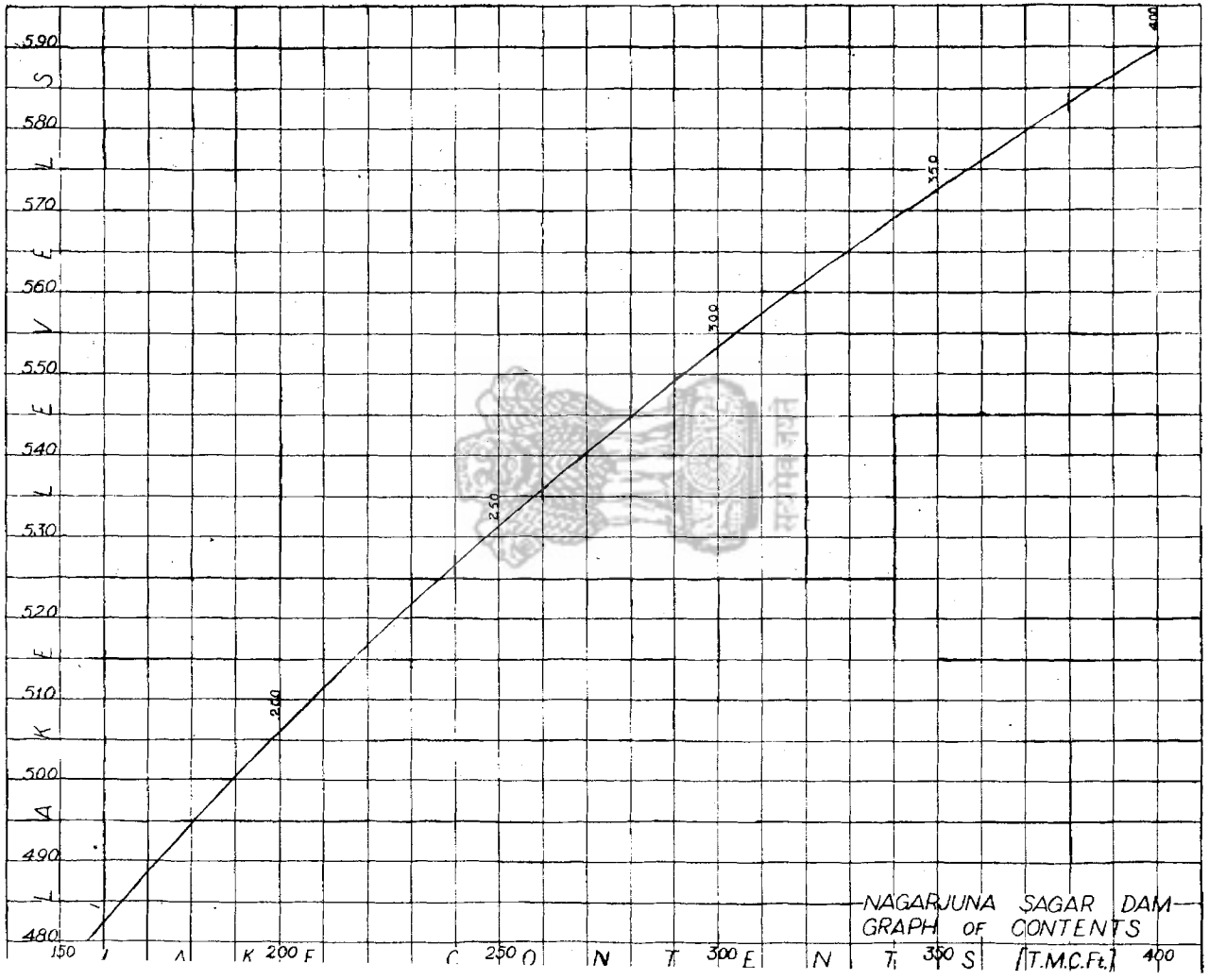
(*e*) 2/3 of Projected irrigation demand of Col. (10) of Working Table I accompanying C.W. & P.C.'s Memo TM-1000-NS-4 on Power Penstocks for Nagarjunsagar excepting demands for second crop.

(*f*) Col. No. (13) of Working Table I accomanying C.W. & P.C.'s Memo TM-1000-NS-4 on Power Penstocks for Nagarjunasagar.

STATEMENT II

New Projects under construction upstream of Nagarjunasagar Dam in First and Second Five Year Plans

Sl. No.	Name of Project	Utilisation T.M.C. Feet
Bombay		
(1)	Ghod	10·0
(2)	Koyna Irrigation and H. E. Scheme	71·0
(3)	Vir Dam	9·4
(4)	Khadakvasla	21·6
(5)	Verna	5·3
(6)	New Medium and Minor Schemes	2·9
	Total	120·2
Mysore		
(1)	Extra for Bhadra Reservoir	18·5
(2)	Tungbhadra High Level Canal	17·0
(3)	Ghatparabha Stage II	36·0
(4)	New Medium and Minor Schemes	10·0
	Total	81·5
Andhra		
(1)	Remodelling of K. C. Canal	27·0
(2)	Bhairvana Tippa	2·0
(3)	Tungbhadra H. L. Canal	32·5
(4)	New Medium and Minor Schemes	9·0
	Total	70·5
	Grand Total of all the three States	272·2


590
580
570
560
550
540
530
520
510
500
490
480
LEVEL IN FEET
150
200
250
300
350
400
CONTENTS (T.M.C.Ft.)
NAGARJUNA SAGAR DAM
GRAPH OF CONTENTS

Working Table No. I-B

*Possible *first phase irrigation with Nagarjunasagar Dam with F.R.L. 546 (crest level of spillway) and minimum working level 504.*

Period		Gauged inflows at Vijayawada (a)	Inflows at N.S. (b)	Demands at N.S.				Lake contents	Surplus	Lake levels	Power Draft		Head at N.S.	Power at N.S. at 100% L.F. (MW)	Power generation with 2×50 MW Turb sets
				First crop (c)	2nd crop (1·25 lakh acres (d)	Firming up power	Total				T.M.C.Ft. (e)	1000 cusecs			
(1)		(2)	(3)	(4) (i)	(4) (ii)	(4) (iii)	(4) (iv)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
								224·4		518·6					
May	II ..	1·7	0·9	5·2	—	0·5	5·7	219·6	—	516·5	2·9	2·21	275·5	38	38
June	I ..	1·3	0·7	8·4	—	—	8·4	211·9	—	512·3	5·0	3·82	272·4	69	69
	II ..	16·2	8·9	24·3	—	—	24·3	196·5	—	504·0	17·0	12·95	266·8	230	100
July	I	153·1	84·7	28·3	—	—	28·3	252·9	—	532·8	7·1	5·41	276·4	96	96
	II ..	451·5	248·3	22·8	—	2·6	25·4	283·0	192·8	546·0	2·6	1·98	297·4	38	38
Aug.	I ..	315·1	174·0	29·0	—	—	29·0	283·0	145·0	546·0	4·8	3·66	304·0	74	74
	II ..	138·6	76·6	27·2	—	0·7	27·9	283·0	48·7	546·0	2·6	1·98	304·0	40	40
Sep.	I ..	47·3	26·1	28·8	—	—	28·8	280·3	—	545·0	7·2	5·49	303·0	111	100
	II ..	183·0	101·3	24·0	—	—	24·0	283·0	74·6	546·0	2·8	2·14	304·0	43	43
Oct.	I ..	268·9	148·5	19·5	—	2·6	22·1	283·0	126·4	546·0	2·6	1·98	304·0	40	40
	II ..	60·7	33·5	29·2	—	—	29·2	283·0	4·3	546·0	8·5	6·48	304·0	131	100
Nov.	I ..	35·1	19·4	29·4	—	—	29·4	273·0	—	541·5	11·7	8·90	301·8	179	100
	II ..	11·0	6·1	25·4	—	—	25·4	253·7	—	533·0	9·6	7·32	295·2	144	100
Dec.	I ..	8·6	4·8	7·0	—	2·6	9·6	248·9	—	530·8	2·6	1·98	289·9	40	40
	II ..	3·8	2·1	0·5	—	2·6	3·1	247·9		530·1	2·6	1·98	288·4	39	39

WORKING TABLE NO. I-B (*contd*)

	(1)		(2)	(3)	(4)(i)	(4)(ii)	(4)(iii)	(4)(iv)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Jan.	I	..	3·0	1·7	0·5	—	2·6	3·1	246·5	—	529·6	2·6	1·98	287·8	39	39
	II	..	2·0	1·1	0·5	—	2·7	3·2	244·4	—	528·6	2·7	2·06	287·1	39	39
Feb.	I	..	1·3	0·7	0·5	2·8	—	3·3	241·8	—	527·3	2·8	2·13	285·9	41	41
	II	..	0·7	0·4	0·5	2·4	0·3	3·2	239·0	—	526·0	2·7	2·06	284·6	39	39
Mar.	I	..	0·4	0·2	0·9	2·8	—	3·7	235·5	—	524·4	2·8	2·13	283·2	40	40
	II	..	0·2	0·1	0·8	2·2	0·6	3·6	232·0	—	522·5	2·8	2·13	281·4	40	40
Apr.	I	..	2·2	1·2	1·1	3·2	—	4·3	228·9	—	521·0	3·2	2·44	279·8	45	45
	II	..	2·1	1·2	1·0	3·2	—	4·2	225·9	—	519·5	3·2	2·44	278·3	45	45
May	I	..	0·9	0·5	1·0	2·8	0·1	3·9	222·5**	—	517·6	2·9	2·21	276·5	41	41
Total		..	1705·7	943·0	315·8	19·4	17·9	353·1		591·8				Average	70	57

Explanations :

(*a*) From figures supplied by Dir. (H. & S.) C.W. & P.C. (Appendix II-B).

(*b*) As per note preceeding Working Table I.

(*c*) As per Col. (6) of Statement I.

(*d*) 1·25/1·5 times column (7) of Statement I.

(*e*) Sum of column (4) (iii) & column 4(ii) of this table & column (2) of Statement I.

*(*i*) 1st crop on delta & L.B.C. & R.B.C. as provided in the Project.

(*ii*) 1¼ lakh acres of 2nd crop on Krishna Delta.

(*iii*) About 40 M.W. of continuous Power.

(*iv*) Future Hydro-potential 70×8760=614 Million KW. hrs.

(*v*) With an installation of 100 M.W. hydro capacity, power potential will be 57×8760=507 Million KW. hrs. which can be generated in 75% dependable year. The installation can operate at 58% L.F. in the interconnected power system.

**Though the lake contents are short by about 1·9 T.M.C.Ft. , they will be made up by savings in evaporation losses, which have been taken the same as for F.R.L. 590.

CHAPTER IV

INTEGRATION OF SRISAILAM AND NAGARJUNASAGAR PROJECTS

4.1.1. The present Nagarjunasagar Project is based on the 1954 Project Report. The construction of the Dam has been divided into two phases. The first phase provides storage upto F.R.L. 525. This gives a total live storage of 65 T.M.C. Feet and provides for irrigation of 20 lakh acres of first crop. The second phase provides storage to F.R.L. 590. This gives a total live storage of 228 T.M.C. Feet or 163 T.M.C. Feet additional over the first phase and provides for irrigation of 28.9 lakh acres of first crop and 2.95 lakh acres of second crop including 0.25 lakh acres of perennial crop in the Delta. The storage provided in the final phase without support from any upper dams is just adequate for the irrigation provided in the Project (Working Table No. II). In discussions this position has been maintained by the Project Authorities too.

4.1.2. While framing the 1954 Project, the working table for F.R.L. 590 was based on the inflows as would be available after the construction of Siddheswaram Dam. The operation levels of the Nagarjunasagar Reservoir showed that the lowest working level of the reservoir would only be 546 against the minimum reservoir level of R.L. 510, which was sufficient for all working operations. If proper integration of the two Dams had been considered, this should have indicated the desirability of lowering the height of Nagarjunasagar Dam considerably, but this aspect does not seem to have been considered as it has not been dealt with anywhere in the 1954 Project Report.

4.2.1. Now that the Srisailam Hydro-electric Project is under active consideration, the Team has looked into the economics of constructing the Nagarjunasagar Dam to a lower F.R.L., which with proper integrated operation of the two Dams would be adequate for all irrigation benefits of Nagarjunasagar scheme as contemplated at present. The Srisailam Project as prepared by the State Government visualises the use of a storage of about 150 T.M.C. Feet. This water is proposed to be let down in regulated flows in non-Monsoon months after deveolping power at Srisailam to be used for irrigation on Nagarjunasagar Project, which otherwise would have to draw this quantity from the storage at Nagarjunasagar. This should normally result in reduction of storage at Nagarjunasagar.

4.2.2. This matter was referred to the Central Water and Power Commission. According to the views of the Team, with integrated operation of Srisailam and Nagarjunasagar Dams full irrigation benefits envisaged in the final phase of the 1954 Project could be obtained with F.R.L. 540 and minimum reservoir level of 510, against F.R.L. 590 and the minimum reservoir level R.L. 510 provided in that Project. The Dam with lower F.R.L. of 540 would have cost Rs. 8 crores less.

4.2.3. The Team has further discussed this question with Central Water and Power Commission who while conceding that the full height is not needed for the irrigation provided in the 1954 Project for the final phase, have stated that :—

> "there is another important aspect of the flows of Krishna river. Andhra gets a little more than 50 per cent of the supplies over and above the supplies available in dependable years. Andhra will, therefore, get 130 T.M.C. Feet when the Krishna flows at Srisailam exceed 1,480 T.M.C. Feet *i.e.* when inflows at Vijayawada exceed 1,730 T.M.C. Feet. A study of the statement showing the annual flows at Vijayawada anicut shows that they exceed 1,800 in 39 out of 56 years. These supplies can be used for additional second crop irrigation in Delta and are, therefore, extremely valuable. They cannot be lost in the long run. Since these supplies are to be stored, it will be necessary to raise the Nagarjunasagar Dam for storing the supplies in any case. The cost now incurred for additional masonry for the widths required for F.R.L. 590 would, therefore, be well justified".

4.2.4. In short, it is now proposed to increase the scope of the Project to do additional unassured irrigation of second crop to the extent it can be done in years of surplus supply over and above seventy-five per cent dependability with F.R.L. 590 of Nagarjunasagar Reservoir. In this connection extract from the note received, from the Central Water and Power Commission is given below :—

> "The amount of extra water available once in two years in excess of 1745 T.M.C. Feet of which Andhra's share is 232 T.M.C. Feet. Assuming that Nagarjunasagar Reservoir is full between 540 to 590 in such years, the water utilised will be 130 T.M.C. Feet. There are about 40 lakh acres of land which can grow a second crop in the Delta and Nagarjunasagar Project areas. However, limiting the area to the water available, at— least 8 lakh acres can be irrigated yielding 3 lakh tons. Taking the cost of Rs. 450 per ton, the cost of food grains would work out to Rs. 13.5 crores. This is equivalent to a food production of Rs. 6.75 crores every year. The annual revenue from 8 lakh acres of biennial second crop irrigation would also be of the order of Rs. 25 lakhs".

Thus the extra height of the Dam over F.R.L. 540 to F.R.L. 590 is now proposed to be justified on consideration of the value of the extra food grains that can be produced from additional second crop in surplus years and some extra revenue that would be realised. These extra benefits, which would accrue as a result of constructing the Nagarjunasagar Dam to F.R.L. 590 have not been taken into account while preparing the 1954 Project. This aspect is dealt with in the subsequent paragraphs with a view to seeing if the extra irrigation benefits would justify the extra capital cost involved in constructing the Dam to the full height, which otherwise is not necessary for the scope of assured irrigation benefits provided in the 1954 Project.

4.3.1. The scope of development of power at Nagarjunasagar is relatively limited. There are, however, favourable sites on the Krishna upstream of Nagarjunasagar Dam for generation of hydro-electric power. These are :

(1) Srisailam and Siddheswaram (Andhra):—Previously two dams, one at Srisailam and the other at Siddheswaram were being considered. Now Srisailam dam is proposed to be raised to a height which would give the F.R.L. which was proposed for Siddheswaram Dam. Both the sites have thus merged into one.

(2) Jaldrug
(3) Hunkunti } Mysore.
(4) Bidri

If water is stored at any of these sites, it can be let down for irrigation at Nagarjunasagar Dam after generation of power, taking care, however, that this is done so that the full irrigation benefits of Nagarjunasagar scheme are assured. Any storages which are meant solely for power upstream of Nagarjunasagar will render the storage at Nagarjunasagar surplus to that extent. All efforts should, therefore, be directed in pursuance of the well known concept that irrigation and power resources in a river valley should be developed in a co-ordinated manner.

4.3.2. A study of the hydro-electric potential of river Krishna has been made by Central Water and Power Commission in their book on 'Hydro-electric Survey of India-East flowing rivers of Southern India'. The power potential at sixty per cent load factor of river Krishna at the stations mentioned above as hown in that Volume is as under :—

	M.W.
(1) Srisailam and Siddheswaram	420
(2) Jaldrug	280
(3) Hunkunti	82
(4) Bidri	72

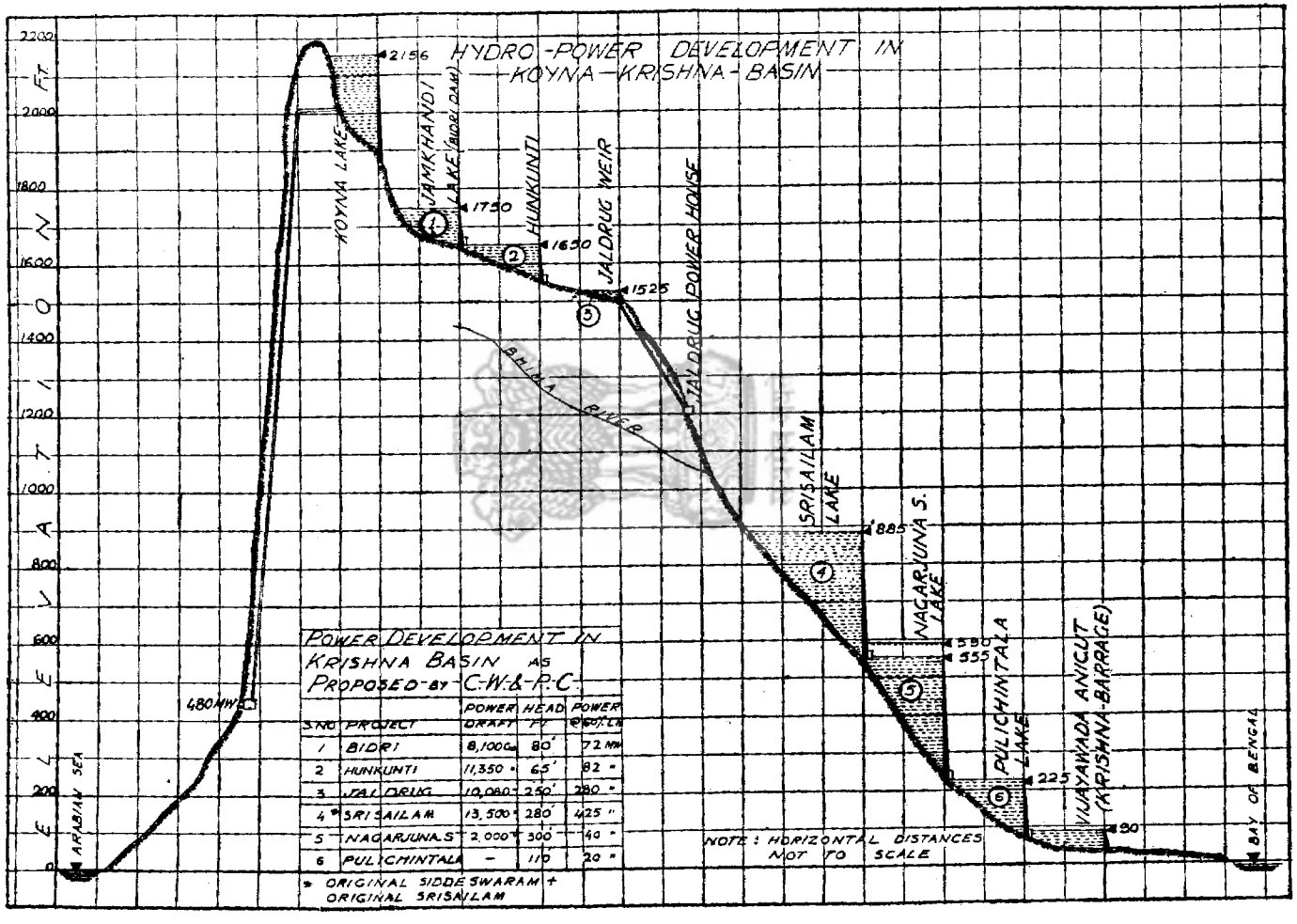
This power potential has been worked out on the basis that inflows of river Krishna at each site in a year of eighty-six per cent dependability less requirements for irrigation upstream and at site will be used for power. This would possibly lead to certain difficulties in the Monsoon months from July to October specially if the hydro-electric Stations are situated in two different States and if the major irrigation is of first crop only, as is proposed in Nagarjunasagar Project. It should be possible to store in upstream reservoirs, the quantity of water required for irrigation during non-Monsoon months from November to June when river flows are not sufficient for the irrigation to be done. In this way the resources of the river can be used for maximum power generation.

4.4.1. The demands at Nagarjunasagar in the dry months are tabulated below :—

		T.M.C. Feet
November	I	42·7
November	II	31·5
December	I	13·3
December	II	15·0
January	I	6·3
January	II	9·6
February	I	9·6
February	II	7·1
March	I	8·5
March	II	8·2
April	I	9·6
April	II	9·3
May	I	8·7
May	II	14·0
June	I	13·6
June	II	27·6
	Total	234·6

This gives an average demand of 14.6 T.M.C. Feet per fortnight. If approximately this much amount of water can be let down in regulated flows from Srisailam Dam in non-Monsoon months and used for irrigation at Nagarjunasagar, the maximum firm power can be generated. If some of these inflows are impounded in hydro-electric dams upstream of Srisailam and similarly let down in the non-Monsoon months increased firm power can be generated at the upper stations also. The use of lower State's share of water for development of power by the upper State has been porvided for in the Memorandum of Agreement of 1951 Award.

4.4.2. The gross-storage of Srisailam Reservoir upto F.R.L. 885 is 308 T.M.C Feet. The Srisailam Hydro-electric Project visualises the use of the storage from R.L. 854 to 885. The storage from 854 to 885 is 150 T.M.C. Feet. The balance storage of 158 T.M.C. Feet is proposed to be treated as a dead storage. In the study that the Team has made for integrated working of the two reservoirs, it will be seen that the power potential at Srisailam can be considerably increased by lowering the minimum draw level of Srisailam Reservoir to R.L. 830; at the same time it will enable lowering of the maximum operational


HYDRO-POWER DEVELOPMENT IN
KOYNA-KRISHNA-BASIN
ELEVATION IN FT.
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
ARABIAN SEA
480MW
KOYNA LAKE
2156
JAMKHANDI LAKE (BIDRI DAM)
1750
HUNKUNTI
1650
JALDRUG WEIR
1525
JALDRUG POWER HOUSE
BALLA RIVER
SRISAILAM LAKE
885
NAGARJUNA S. LAKE
590
555
PULICHINTALA LAKE
225
VIJAYAWADA ANICUT (KRISHNA BARRAGE)
80
BAY OF BENGAL
POWER DEVELOPMENT IN KRISHNA BASIN AS PROPOSED BY C.W.&P.C.
S.NO | PROJECT | POWER DRAFT | HEAD FT | POWER @60% L.F.
1 | BIDRI | 8,100 cs | 80' | 72 MW
2 | HUNKUNTI | 11,350 " | 65' | 82 "
3 | JALDRUG | 10,080 " | 250' | 280 "
4 | SRISAILAM | 13,500 " | 280' | 425 "
5 | NAGARJUNA S. | 2,000 " | 300 | 40 "
6 | PULICHINTALA | — | 110 | 20 "
* ORIGINAL SIDDESWARAM + ORIGINAL SRISAILAM
NOTE : HORIZONTAL DISTANCES NOT TO SCALE

level at Nagarjunasagar for assured irrigations. The lowered operation level will result in increased storages at Nagarjunasagar for use in secondary irrigation.

4.4.3. The Central Water and Power Commission have supplied tne Team with two tables, one for Srisailam Reservoir and the other for Nagarjunasagar Reservoir, copies of which are at Appendices IV and IV-A. In the case of Nagarjunasagar Reservoir, the minimum working level has been taken as 530 against 510 as hown in 1954 Project. The resorvoir level goes upto R.L. 566 only. The operative storage is thus only 82 T.M.C. Feet out of 228 T.M.C. Feet. The minimum operating level has been raised in view of the changes made in the full supply level of the Canals, specially of the Left Bank Canal and some carry-over provided in case of failure of early Monsoon rains. The inflows at Srisailam are shown very much higher than those given by the Central Water and Power Commission in connection with the availability of water at various points of the river Krishna (Appendices II and II-A.) The requirements of irrigation for the Left Bank Canal and the Delta are also different from those supplied by the Project Authorities. The Central Water and Power Commission have since agreed at the meeting held on 5th November, 1959, that figures of demands as given by the Proejct Authorities may be adopted and the Team has done so in its tables. The figures for irrigation demands for Krishna-Pennar Cannal at Srisailam are the same as provided in Srisailam Hydro-electric Project.

4.5.1. The Team has prepared two Working Tables No. III and IV on the basis of the yield of river Krishna at Srisailam and Nagarjunasagar as provided in 1954 Project and confirmed by the Central Water and Power Commission and irrigation demands as given by the Project Authorities and accepted by the Central Water and Power Commission (Appendix II). Working Table No. III is prepared on the basis of the operation of the two Reservoirs as adopted by the Central Water and Power Commission and the Project Authorities in Srisailam Hydro-electric Project.

During discussions on 25th and 26th March 1959, the Project Authorities have expressed that with the Left Bank Canal full supply level of R.L. 524.58 as proposed at present, the minimum working level of Nagarjunasagar Reservoir of R.L. 520 would be adequate as against R.L. 530 shown by Central Water and Power Commission and provided in Srisailam Project, as a large carry-over in case of failure of early Monsoon rains, was not considered necessary, with which the Team agrees. In view of this, Working Table No. III has been prepared with the minimum draw-down level of R.L. 520.

Working Table No. IV is based on the integrated operation of the two Dams as proposed by the Team, with two alternative minimum reservoir levels of R.L. 520 and R.L. 510. In connection with the design of the Left Bank Canal, the Team has suggested the lowering of the full supply level by ten feet, which will enable the minimum reservoir level of Nagarjunasagar to be kept at R.L. 510 as originally proposed in the 1954 Project. The Team has taken the two draw-down

levels of 520 and 510 with a view to working out the comparative advantages of lowering the full supply level of the Left Bank Canal by ten feet.

4.5.2. It may be mentioned that the minimum tail water level for generation of power at Srisailam is R.L. 540. Any higher working level of Nagarjunasagar Reservoir will, therefore, back against the Srisailam Dam and affect the power head. In working operations of the Nagarjunasagar Dam, it would, therefore, be desirable to keep the operation level as low as possible.

4.5.3. From Table No. III, it will be seen that the maximum operation level works to about R.L. 565 and in Table No. IV, to R.L. 553, for minimum operation level of 520 for full irrigation with seventy-five per cent dependability. The power flows from Srisailam for generation of firm power in non-Monsoon months in Table No. IV proposed by the Team, are so regulated that the total flows from November to June nearly amount to the requirements of irrigation at Nagarjunasagar in these months. In this method of working maximum firm power can be generated at Srisailam and at the same time, the additional second crop in years of surplus supply over seventy-five per cent dependability at Nagarjunasagar will also increase as the maximum operation level for assured irrigation works out to R.L. 553 in Table No. IV against R.L. 565 in Table No. III.

4.5.4. The average firm power generated at Srisailam at sixty per cent load factor in Table No. IV as proposed by the Team is 377 MW and in Table No. III as proposed by Central Water and Power Commssion is 260 MW. The Team has drawn upon the storage at Srisailam to the extent of 210 T.M.C. Feet by lowering the level to R.L. 830. The storage below 830 which amounts to 98 T.M.C. Feet will serve as a dead storage and partly as an emergency reserve upto R.L. 790.

4.5.5. Refering again to Table No. IV, it will be noticed that the Srisailam lake level is drawn down below R.L. 854 during three fortnights, *i.e.* June I, June II and July 1. The lake level is below the supply level of Krishna—Pennar Canal in this period when the canal has to have supplies for irrigation. Perhaps it is for this reason that the lake level is not drawn down below R.L. 854 in the Central Water and Power Commission's Working Table, which results in lower power generation at Srisailam Dam. It is feasible to instal suitable reversible hydro-generating sets at Krishna—Pennar Canal intake; these units will be generating power normally; when reversed, they can pump water into the Krishna—Pennar Canal when lake levels are lower than canal supply level. The power required for pumping in the three fortnights is small compared with extra generation of 117 MW of firm power which is possible by lowering the Srisailam lake level to R.L. 830. However, it should be recognised that construction of any of the other proposed power reservoirs upstream of Srisailam will enable maintaining of minimum reservoir level at Srisailam above 854. As such power potentials will be exploited in due course, the installation of pumping scheme at Srisailam may be determined with reference to the phasing of these Projects.

4.5.6. The savings in the power system due to extra generation of hydro-energy will amount to not less than Rs. 62.5 lakhs per annum (Statement IV). The second benefit following from the integration suggested by the Team will be that about 0.76 lakh acres of extra second crop can be obtained on an average in surplus years (Statement III.)

4.5.7. For the scope of irrigation and design features of the canals as provided in the 1954 Project Report, the Nagarjunasagar Dam, if properly integrated with Srisailam Dam, could have been constructed with F.R.L. 540. Due to the increased scope of irrigation as a result of Left Bank Canal extension, the F.R.L. of 544 will be adequate for full irrigation provided in the 1954 Project and the additional 3.5 lakh acres on the Left Bank Canal extension (Working Table No. IV).

4.6.1. As the Dam is already under construction with full section for F.R.L. 590, it has been suggested by the Central Water and Power Commission that the extra storage will be very useful for raising additional second crop in surplus years.

4.6.2. The Team has prepared Statement III for sixty-five years showing the use that can be made of surplus storage in years of surplus supply over seventy-five per cent dependability. It will be seen from this statement that if the minimum operational level is kept at R.L. 520 and Central Water and Power Commission's method of operation adopted, the extra second crop irrigation that can be done annually on an average will amount to 1.65 lakh acres. With minimum levels of 520 and 510 and operation method suggested by the Team, the additional annual second crop irrigation will be 2.91 and 3.33 lakh acres respectively.

4.6.3. The extra cost of construction of the Dam over F.R.L. 544 upto F.R.L. 590 will be about Rs. 7.5 crores. The percentage revenue from the additional second crop irrigation on this extra capital cost on the basis of water cess rate of Rs. 7.50 per acre as adopted in the revised financial forecast, under the three alternative methods of operation mentioned above are worked out in Statement III. These are :

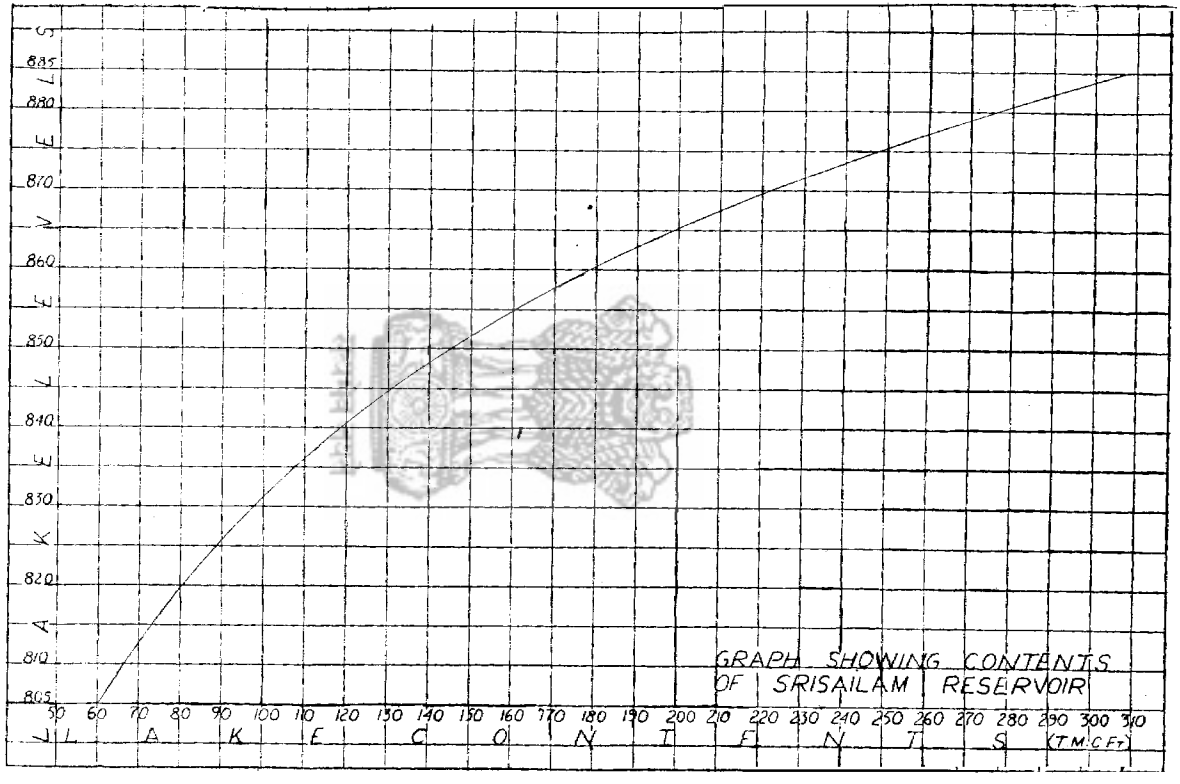
	Minimum working level at N.S.	Extra Second crop Lakh Acres	Extra Revenue (Rs. lakhs) @Rs. 7·50 per acre	Per cent return on Rs. 7·5 crores invest-ment
I. C.W. & P.C. 's method of operation	520	2·15	16·1	2·1
II. Team's method of operation	520	2·91	21·1	2·9
III. Team's method of operation and lowering F.S.L. of Left Bank Canal by 10 feet.	510	3·33	25·0	3·3

The actual saving, if the Dam height was now reduced, will be much less than Rs. 7.5 crores, as the Dam is being constructed for the full section required for F.R.L. 590.The percentage revenue return on the capital of Rs. 7.5 crores compares favourably with the return expected from the first phase Project, which, according to the revised financial forecast, is only 2.2 per cent.

4.6.4 From general considerations and the fact that the extra storage will provide irrigation for additional second crop, which apart from giving the additional revenue will give extra food grains of considerable value, it would not be desirable to reduce the height of the Dam at this stage. However, in the final financial forecast, credit should be taken for the revenue from the additional second crop.

4.6.5. While working out the finacial return for additional second crop, the Team has adopted Rs. 7.50 per acre as water cess which has been provided in the revised financial forecast. Considering the fact that the second crop irrigation has to be done entirely with costly storage water, the Team suggests that the water cess rate for the second crop may be raised from Rs. 7.50 per acre to Rs. 12 per acre which compared to the rate of Rs. 15 per acre for the first crop wet, is well justified. This, apart from increasing the return from the extra capital involved, will improve the financial return from the Project in general.

4.7. In conclusion the Team would suggest that the integration aspect of the various projects in one river valley basin should be given full consideration by Central Water and Power Commission in examining such schemes.


LAKE LEVELS
885
880
870
860
850
840
830
820
810
805
50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310
LAKE CONTENTS (TMC Ft)
GRAPH SHOWING CONTENTS OF SRISAILAM RESERVOIR

Note on inflows adopted in the Working Tables No. II, III & IV for the year 1937-38.

As shown in the note on inflows adopted for Working Table No. I, the available inflows at Srisailam for a dependable year (with guaged inflows of 1480 T.M.C.Feet at Vijayawada), are 527 T.M.C.Feet.

2. In the year 1937-38, as the guaged inflows at Vijayawada are 1706 T.M.C.Feet, the total extra yields over and above the dependable in flows = 1706-1480 = 226 T.M.C. Feet. Out of this, the share of Andhra at 53.5% is 121 T.M.C. Feet. The extra yield between Srisailam and Vijayawada at fifteen per cent of total is $0.15 \times 226 = 34$ T.M.C.Feet. Therefore the net yield at Srisailam = $527 + 121 - 34 = 614$ T.M.C. Feet.

3. The yield from Srisailam to Nagarjunasagar at 2¼ per cent of the total = 2.25 (1706 + 265)/100 = 44 T.M.C.Feet. As the existing works abstract 4 T.M.C.Feet out of these the yields at Nagarjunasagar, when there is no Srisailam Reservoir would be = 614 + 44 — 4 = 654 T.M.C.Feet.

4. When Srisailam Reservoir comes into operation the evaporation loss and irrigation requirements there would be 32.5 and 41.0 T.M.C.Feet respectively, and therefore, the net inflows at Nagarjunasagar then would be = 654 — (32.5 + 41.0) = 580.5 T.M.C. Feet.

WORKING TABLE II

For Nagarjunasagar Dam alone for year 1937-38 (75% *dependability*) *with demand as per project inclusive of* 20 *T.M.C. Feet for firming up power.*

Period		Guaged inflows at Vijaya-wada (a)	Net inflows at Nagarjun-sagar (b)	Demand for full (original) irriga-tion & firming up power (c)	Lake contents	Surplus	Lake Levels
(1)		(2)	(3)	(4)	(5)	(6)	(7)
					233·5		522·4
May	II ..	1·7	0·7	13·8	220·4	—	516·6
June	I ..	1·3	0·5	13·4	207·9	—	510·0
	II ..	16·2	6·2	27·0	186·7	—	498·5
July	I ..	153·1	58·7	41·8	203·6	—	507·6
	II ..	451·5	172·5	40·1	336·0	—	565·2
Aug.	I ..	315·1	123·8	44·2	400·0	15·6	590·0
	II ..	138·6	53·1	44·3	400·0	8·8	590·0
Sep.	I ..	47·3	18·1	43·0	375·1	—	581·5
	II ..	183·0	70·2	38·4	400·0	6·9	590·0
Oct.	I ..	268·9	100·9	33·2	400·0	67·7	590·0
	II ..	60·7	23·3	41·6	382·8	—	584·0
Nov.	I ..	35·1	13·4	40·6	354·6	—	574·0
	II ..	11·0	4·2	29·2	325·6	—	564·8
Dec.	I ..	5·6	2·1	12·7	319·0	—	561·0
	II ..	3·8	1·4	14·8	305·6	—	555·6
Jan.	I ..	3·0	1·1	6·3	300·4	—	553·8
	II ..	2·0	0·8	9·6	291·8	—	550·0
Feb.	I ..	1·3	0·5	9·6	282·5	—	545·9
	II ..	0·7	0·3	7·1	275·7	—	542·8
Mar.	I ..	0·4	0·2	8·5	267·4	—	539·0
	II ..	0·2	0·1	8·2	259·2	—	535·5
Apr.	I ..	2·2	0·8	9·6	250·4	—	531·4
	II ..	2·1	0·8	9·3	241·9	—	528·2
May	I ..	0·9	0·3	8·7	233·5	—	522·4
	Total ..	1,705·7	654·0	555·0		99·0	

Explanations :—

(*a*) Figures supplied by Dir. (H. & S.), C.W. & .P.C. (Appendix II-B).

(*b*) As per note preceding the Working Table.

(*c*) As per Statement II.

WORKING TABLE III

Combined operation of Srisailam (F.R.L. 885 Minimum Working Level 854) and Nagarjunasagar (Minimum Working Level 520) with power flow pattern at Srisailam as proposed by the Central Water and Power Commission and irrigation demands at Nagarjunasagar as per Project Authorities, and irrigation demand for Krishna–Pennar Canals as supplied by Central Water and Power Commission for the year 1937-38 which corresponds to about 75 per cent dependability.

Period		Guaged inflows at Vijayawada (a)	Inflows at Srisailam (b)	Irrigation at K.P.C. (c)	Power draft (d)	Evaporation	Total Demand	Storage	Surplus	Lake levels at Srisailam	Power at Srisailam				
											Mean Lake level	Head at Srisailam	Power Draft (1000 cusecs)	Power at 100% L. F. (MW)	
														Total	Limited to 660 MW
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
								185·9		861·3					
May	II ..	1·7	0·6	—	9·3	1·6	10·9	175·6	—	858·5	859·9	317·9	7·09	150	150
June	I ..	1·3	0·5	0·4	9·3	1·1	10·8	165·3	—	856·0	857·2	315·2	7·09	149	149
	II ..	16·2	5·8	0·2	9·8	1·1	11·1	160·0	—	854·2	855·1	313·1	7·48	156	156
July	I ..	153·1	55·1	6·0	40·0	0·9	46·9	168·2	—	856·6	855·4	313·4	30·50	638	638
	II ..	451·5	162·3	6·6	40·0	1·1	47·7	282·8	—	881·2	868·9	326·9	30·50	665	660
Aug.	I ..	315·1	113·5	7·2	40·0	1·6	48·8	308·0	39·5	885·0	883·1	341·1	30·50	694	660
	II ..	138·6	49·9	7·7	40·0	1·6	49·3	308·0	0·6	885·0	885·0	343·0	30·50	694	660
Sep.	I ..	47·3	17·0	5·6	40·0	1·6	47·2	277·8	—	880·2	882·6	340·6	30·50	692	660
	II ..	183·0	65·9	1·5	40·0	1·7	43·2	300·5	—	883·7	882·0	340·0	30·50	692	660
Oct.	I ..	268·9	96·8	1·3	40·0	1·7	43·0	308·0	46·3	885·0	884·4	331·9	30·50	671	660
	II ..	60·7	21·9	1·4	24·8	1·7	27·9	302·0	—	884·0	884·5	321·5	18·90	403	403
Nov.	I ..	35·1	12·6	1·2	9·3	1·1	11·6	303·0	—	884·1	884·1	331·4	7·09	156	156
	II ..	11·0	4·0	1·2	9·3	1·1	11·6	295·4	—	883·0	883·6	341·6	7·09	161	161

WORKING TABLE III (*contd.*)

(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Dec.	I ..	5·6	2·0	0·3	9·3	1·0	10·6	286·8	—	881·7	882·3	340·3	7·09	161	161
	II ..	3·8	1·4	0·4	9·3	1·0	10·7	277·5	—	880·2	881·0	339·0	7·09	160	160
Jan.	I ..	3·0	1·1	—	9·3	1·0	10·3	268·3	—	878·8	879·5	337·5	7·09	160	160
	II ..	2·0	0·7	—	9·3	0·9	10·2	258·8	—	876·2	877·5	335·5	7·09	158	158
Feb.	I ..	1·3	0·5	—	9·3	0·9	10·2	249·1	—	875·2	875·7	333·7	7·09	158	158
	II ..	0·7	0·3	—	9·3	0·8	10·1	239·3	—	873·2	874·2	332·2	7·09	157	157
Mar.	I ..	0·4	0·2	—	9·3	1·8	11·1	228·4	—	871·2	872·2	330·2	7·09	156	152
	II ..	0·2	—	—	9·3	1·6	10·9	217·5	—	868·8	870·0	328·0	7·09	155	155
Apr.	I ..	2·2	0·8	—	9·3	2·0	11·3	207·0	—	866·5	867·2	325·2	7·09	154	154
	II ..	2·1	0·8	—	9·3	1·9	11·2	196·6	—	864·0	864·7	322·7	7·09	152	152
May	I ..	0·9	0·3	—	9·3	1·7	11·0	185·9	—	861·3	862·7	320·7	7·09	152	152
Total	.. ..	1705·7	614·0	41·0	454·1	32·5	527·6		86·4				Average Power	156 (Firm)	312·3 (Total)

WORKING TABLE III—*(contd.)*

Period		Interim flows between Srm. and N.S.	Total Inflows at N.S. (5)+(9)+(16)	Demand at N.S. (Assured) irrigatin & Power				Lake contents at N.S.	Lake levels at N.S..	Power at Nagarjunasagar (Minimum Working Level 520)			
				Original irrigation & power (e)	*Extension on L.B.C. (2·12 L. Acres) (f)	Evaporation	Total Demand			Mean Lake Level	Head	Power Draft (1000 cusecs) (g)	Power at 100% L.F. (MW)
(1)		(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)
								253·8	532·9				
May	II	—	9·3	12·7	0·2	1·1	14·0	249·1	530·8	531·8	289·8	7·58	146
June	I	—	9·3	12·6	0·2	0·8	13·6	244·8	529·0	529·9	287·9	6·73	129
	II	0·5	10·3	26·2	0·6	0·8	27·6	227·5	520·3	524·6	282·6	13·00	245
July	I	3·6	43·6	41·3	2·3	0·5	44·1	227·0	520·0	520·2	278·2	5·66	105
	II	10·5	50·5	39·5	2·5	0·6	42·6	234·9	524·0	522·0	280·0	2·29	43
Aug.	I	7·4	86·9	43·6	2·5	0·6	46·7	275·1	542·4	533·2	291·2	4·07	79
	II	3·3	43·9	43·6	2·8	0·7	47·1	271·9	540·9	541·6	299·6	2·34	47
Sep.	I	1·1	41·1	42·2	2·5	0·8	45·5	267·5	539·1	540·0	298·0	5·79	115
	II	4·3	44·3	37·6	2·5	0·8	40·9	270·9	540·5	539·8	297·8	2·38	47
Oct.	I	6·3	92·6	32·5	1·9	0·7	35·1	328·4	564·5	552·5	310·5	2·04	42
	II	1·4	26·2	40·9	2·3	0·7	43·9	320·7	561·5	563·0	321·0	6·70	139
Nov.	I	0·8	10·1	40·2	2·1	0·4	42·7	278·1	543·9	552·7	310·7	0·09	188
	II	0·3	9·6	28·8	2·3	0·4	31·5	256·2	534·1	539·0	297·0	2·12	42
Dec.	I	0·3	9·6	12·3	0·6	0·4	13·3	252·5	532·3	533·2	291·2	2·16	42
	II	0·2	9·5	14·4	0·2	0·4	15·0	247·5	530·0	531·2	289·2	2·33	45

WORKING TABLE III (*contd.*)

(1)		(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)
Jan.	I	—	9·3	5·9	—	0·4	6·3	250·0	531·2	530·6	288·6	2·18	42
	II	—	9·3	9·2	—	0·4	9·6	249·7	531·0	531·1	289·1	2·32	45
Feb.	I	—	9·3	9·2	—	0·4	9·6	249·4	531·0	531·0	289·0	2·94	57
	II	—	9·3	6·7	—	0·4	7·1	251·6	532·0	531·5	289·5	2·56	49
Mar.	I	—	9·3	7·7	—	0·8	8·5	252·4	532·3	532·2	290·2	2·95	57
	II	—	9·3	7·4	—	0·8	8·2	253·5	532·9	532·6	290·6	2·44	47
Apr.	I	—	9·3	8·5	—	1·1	9·6	253·2	532·8	532·8	290·8	3·47	67
	II	—	9·3	8·2	—	1·1	9·3	253·2	532·8	532·8	290·8	3·47	67
May	I	—	9·3	7·6	—	1·1	8·7	253·8	532·9	532·9	290·9	2·98	58
		40·0	580·5	538·8	25·5	16·2	580·5						

Explanations:—

(*a*) From figures supplied by Dir. (H. & S.) C.W. & P.C. (Appendix II-B.).

(*b*) Availability of 614 T.M. C.Ft. as per covering note and detailed figures in proportion to Col. (2).

(*c*) As supplied by C.W. & P.C.

(*d*) Firm power draft as per C.W. & P.C.'s latest Working Table.

(*e*) As per Working Table supplied by Project Authorities. (Statement II).

(*f*) Actual intended irrigation is 3·5 lakhs, needing 42 T.M.C. ft. as per figures supplied by Project Authorities. Since only 25½ T.M.C. Ft. of water are available at 75% dependability for this the actual irrigation is possible on only 1·12 lakh acres.

(*g*) As per Col. 7 of Statement II—A.

Working Table IV

For combined operation of Srisailam Reservoir (F.R.L. 885 and Minimum Working Level 830) and Nagarjunasagar Reservoir for the year 1937-38 (with 75% dependability) with irrigation demand as supplied by Project Authorities with minimum working levels at Nagarjunasagar at (i)520 and (ii) 510.

Period		Guaged inflows at Vijayawada (a)	Inflows at Srisailam (b)	Draft at Srisailam				Lake contents	Surplus	Lake levels	Power at Srisailam				
				Irrigation at K.P.C. (c)	Power	Evaporation	Total				Mean Lake level	Head at Srisailam	Power flows (1000 cusecs)	Power (MW) at 100% L.F.	
														Total	Limited to 660 MW
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
								136·0		847·0					
May	II ..	1·7	0·6	—	13·6	1·6	15·2	121·4	—	841·3	844·0	302·0	10·36	209	209
June	I ..	1·3	0·5	0·4	13·6	1·1	15·1	106·8	—	834·7	838·0	296·0	10·36	205	205
	II ..	16·2	5·8	0·2	13·6	1·1	14·9	97·7	—	830·0	832·4	290·4	10·36	201	201
July	I ..	153·1	55·1	6·0	40·5	0·9	17·4	105·4	—	834·0	832·0	290·0	30·90	598	598
	II ..	451·5	162·3	6·6	32·1	1·1	39·8	227·9	—	871·0	852·5	310·5	24·50	507	507
Aug.	I ..	315·1	113·5	7·2	39·3	1·6	48·1	293·3	—	883·0	877·0	335·0	30·00	670	660
	II ..	138·6	49·9	7·7	43·8	1·6	58·1	290·1	—	882·5	882·7	340·7	33·40	759	660
Sep.	I ..	47·3	17·0	5·6	44·4	1·6	51·6	255·5	—	876·3	879·4	337·4	33·86	785	660
	II ..	183·0	65·9	1·5	36·6	1·7	39·8	281·6	—	880·9	878·6	336·6	27·90	626	626
Oct.	I ..	268·9	96·8	1·3	28·8	1·7	31·8	308·0	38·6	885·0	883·0	341·0	29·60	674	660
	II ..	60·7	21·9	1·4	18·8	1·7	21·9	308·0	—	885·0	885·0	343·0	14·32	328	328

WORKING TABLE IV (*contd.*)

(1)			(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Nov.	I	..	35·1	12·6	1·2	13·6	1·1	15·9	304·7	—	884·5	884·7	342·7	10·36	237	237
	II	..	11·0	4·0	1·2	13·6	1·1	15·9	292·3	—	883·0	883·7	341·7	10·36	236	236
Dec.	I	..	5·6	2·0	0·3	13·6	1·0	14·9	279·9	—	880·5	882·2	340·2	10·36	235	235
	II	..	3·8	1·4	0·4	13·6	1·0	15·0	266·3	—	878·3	879·4	337·4	10·36	233	233
Jan.	I	..	3·0	1·1	—	13·6	1·0	14·6	252·8	—	875·8	877·0	335·0	10·36	231	231
	II	..	2·0	0·7	—	13·6	0·9	14·5	239·0	—	873·2	874·5	332·5	10·36	230	230
Feb.	I	..	1·3	0·5	—	13·6	0·9	14·5	225·0	—	870·3	871·7	329·7	10·36	228	228
	II	..	0·7	0·3	—	13·6	0·8	14·4	210·9	—	867·4	868·8	326·8	10·36	226	226
Mar.	I	..	0·4	0·2	—	13·6	1·8	15·4	195·7	—	864·2	865·8	321·8	10·36	222	222
	II	..	0·2	—	—	13·6	1·6	15·2	180·5	—	860·4	862·3	320·3	10·36	221	221
Apr.	I	..	2·2	0·8	—	13·6	2·0	15·6	165·7	—	856·4	858·4	316·4	10·36	219	219
	II	..	2·1	0·8	—	13·6	1·9	15·5	151·0	—	852·2	854·3	312·3	10·36	216	216
May	I	..	0·9	0·3	—	13·6	1·7	15·3	136·0	—	847·0	849·6	307·6	10·36	213	213
	Total	..	1705·7	614·0	41·0	501·9	32·5	575·4		38·6				Average Power	226 (firm)	344·3

WORKING TABLE IV *(contd.)*

		Interim flows from Srm. to N.S. (d)	Total In-flows at N.S. (5)+ (9)+ (16)	Total demand at N.S. (e)	I Min. draw down L-520		II. Minimum draw down level at N.S. 510					
					Lake contents at N.S.	Lake levels at N.S.	Lake contents at N.S.	Lake levels at N.S.	Mean Lake Levels	Head at N.S. (22)— 242	Power Draft (T.C. Cus.) (f)	Power in MW 100% L.F.
	(1)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
					272·5	542·1	253·0	532·5				
May	II ..	—	13·6	14·0	272·0	541·0	252·5	532·3	532·4	290·4	7·58	147
June	I ..	—	13·6	13·6	272·0	541·0	252·5	532·3	532·3	290·3	6·73	130
	II ..	0·5	14·1	27·6	258·5	535·0	239·0	526·0	529·2	287·2	13·00	249
July	I ..	3·6	44·1	44·1	253·5	535·0	239·0	526·0	526·0	284·0	5·66	107
	II ..	10·5	42·6	42·6	258·5	535·0	239·0	526·0	526·0	284·0	2·29	43
Aug.	I ..	7·4	46·7	46·7	258·5	535·0	239·0	526·0	526·0	284·0	4·07	77
	II ..	3·3	47·1	47·1	258·5	535·0	239·0	526·0	526·0	284·0	2·34	44
Sep.	I ..	1·1	45·5	45·5	258·5	535·0	239·0	526·0	526·0	284·0	5·79	110
	II ..	4·3	40·9	40·9	258·5	535·0	239·0	526·0	526·0	284·0	2·88	45
Oct.	I ..	6·3	73·7	35·1	297·1	552·3	277·6	543·7	534·9	292·9	2·04	40
	II ..	1·4	20·2	43·9	273·5	541·6	254·0	533·0	538·3	296·3	6·70	102
Nov.	I ..	0·8	14·4	42·7	245·1	529·0	225·6	519·2	526·1	284·1	9·09	172
	II ..	0·3	13·9	31·5	227·6	520·4	208·1	510·2	514·7	272·7	2·12	39
Dec.	I ..	0·3	13·9	13·3	228·2	520·6	208·7	510·5	510·3	268·3	2·16	39
	II ..	0·3	13·8	15·0	227·0	520·0	207·5	510·0	510·3	268·3	2·33	42

WORKING TABLE IV (*contd.*)

(1)		(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
Jan.	I ..	—	13·6	6·3	234·3	523·8	214·8	513·5	511·8	269·8	2·18	39
	II ..	—	13·6	9·6	238·3	525·6	218·8	515·7	514·6	272·6	2·32	42
Feb.	I ..	—	13·6	9·6	242·3	527·6	222·8	517·7	516·7	274·7	2·94	54
	II ..	—	13·6	7·1	249·1	530·7	229·6	521·5	519·6	277·6	2·56	47
Mar.	I ..	—	13·6	8·5	253·9	533·0	234·4	523·8	522·7	280·7	2·55	55
	II ..	—	13·6	8·2	259·3	535·5	239·8	526·5	525·2	283·2	2·44	46
Apr.	I ..	—	13·6	9·6	263·3	537·2	243·8	528·2	527·4	285·4	3·47	65
	II ..	—	13·6	9·3	267·6	539·1	248·1	530·3	529·2	287·2	3·47	66
May	I ..	—	13·6	8·7	272·5	542·1	253·0	532·5	531·4	289·4	2·98	57
	Total :	40·00	580·5	580·5								

Explanations :

(*a*) Figures supplied by Dir. (H. & S.), C.W. & P.C. (Appendix II-B).

(*b*) As per note preceding Working Table II.

(*c*) As per C.W. & P.C.'s Working Tables.

(*d*) As per note preceding Working Table II.

(*e*) As per Col. (21) of Working Table III.

(*f*) As per Col. 7 of Statement II-A.

STATEMENT II

Demands for Nagarjunasagar Dam (Final Phase)

Month & period		Copy of Demand Figures in M. C.Ft. supplied by Nagarjunasagr Project Authorities						
		Krishna Delta New I crop 1·5 lakhs II crop 1·5 lakhs	0·25 lakhs perennial in Krishna Delta	Nandi-konda right Canal 14·7 lakhs I crop 1/3 wet 2/3 dry	Puli-chintala ayacut under N.R. canal 1/3 wet 2/3 dry	Kavali Canal 1·1 lakhs I crop wet.	Kanupur Canal 0·78 lakhs I crop wet.	Hyderabad State 6·75 lakhs I crop 1·2 lakhs II crop
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)
May	II	9,352	580	1,201	163	—	—	1,201
June	I	9,352	23	1,639	223	—	—	1,639
	II	20,492	23	4,004	545	—	—	4,004
July	I	21,859	416	15,548	2,115	1,630	1,150	11,180
	II	17,507	444	16,548	2,250	1,730	1,220	12,400
Aug.	I	18,675	484	17,587	2,405	1,800	1,270	12,760
	II	15,582	517	19,608	2,667	1,910	1,350	12,300
Sep.	I	15,582	358	15,337	2,085	1,950	1,370	11,700
	II	14,870	360	15,438	2,099	2,100	1,480	11,170
Oct.	I	15,861	273	13,138	1,786	1,130	800	11,170
	II	12,943	292	16,308	2,218	1,200	850	9,260
Nov.	I	12,943	166	13,064	1,776	1,600	1,130	8,811
	II	—	166	14,398	1,958	1,700	1,200	4,750
Dec.	I	—	39	2,848	388	1,220	870	3,750
	II	—	42	—	—	1,300	920	9,145

STATEMENT II (*contd.*)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Jan.	I	.. ..	—	544	—	—	—	—	2,987
	II	.. ..	—	580	—	—	—	—	6,140
Feb.	I	.. ..	3,334	544	—	—	—	—	5,375
	II	.. ..	2,898	471	—	—	—	—	3,375
Mar.	I	.. ..	3,334	540	—	—	—	—	3,840
	II	.. ..	2,652	580	—	—	—	—	4,066
Apr.	I	.. ..	3,920	653	—	—	—	—	3,813
	II	.. ..	3,920	653	—	—	—	—	3,077
May	I	.. ..	3,376	543	—	—	—	—	3,077
		Total ..	2,08,452	9,291	1,66,666	22,678	19,270	13,610	1,60,990

STATEMENT II (*contd.*)

Demands for Nagarjunasagar Dam (Final Phase)

		Nandigama Block 2·05 lakhs 1/3 wet 2/3 dry	Total Demand	Intermediate flow bet. N.S.P. & Vijayawada 50% only	Net demand for irrigation	For power	Total Demand including power	Evaporation (a)	Total Demand-Col. (14) + (15) in 1000 M. C.Ft.
(I)		(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
May	II	168	12,665	—	12,665	—	12,665	1,244	13·9
June	I	229	13,105	559	12,546	—	12,546	914	13·4
	II	560	29,628	3,438	26,190	—	26,190	900	27·0
July	I	2,170	56,068	14,746	41,322	—	41,322	588	41·9
	II	2,310	54,409	25,085	36,458	3,000	39,458	592	40·0
Aug.	I	2,460	57,441	13,820	43,621	—	43,621	622	44·3
	II	2,739	56,673	13,708	42,965	679	43,644	596	44·3
Sep.	I	2,140	50,522	8,346	42,176	—	42,176	576	42·8
	II	2,150	49,667	12,111	37,559	—	37,556	585	38·2
Oct.	I	1,835	45,993	22,533	29,859	2,677	32,536	609	33·1
	II	2,280	45,351	4,443	40,908	—	40,908	766	41·6
Nov.	I	1,820	41,310	1,196	40,114	—	40,114	477	40·6
	II	2,002	26,174	888	26,008	,2780	28,788	438	29·2

STATEMENT II (*concld*)

(1)			(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Dec.	I	.. .. ..	397	9,512	454	9,473	2,833	12,306	414	12·7
	II	.. .. ..	—	11,407	329	11,365	3,051	14,416	409	14·8
FJan.	I	.. .. ..	—	3,531	148	3,383	2,474	5,857	398	6·2
	II	.. .. ..	—	6,720	89	6,631	2,552	9,183	400	9·5
eb.	I	.. .. ..	—	9,253	32	9,221	—	9,221	398	9·6
	II	.. .. ..	—	6,744	14	6,730	—	6,730	398	7·1
Mar.	I	.. .. ..	—	7,714	—	7,714	—	7,714	894	8·6
	II	.. .. ..	144	7,442	30	7,412	—	7,412	906	8·3
Apr.	I	.. .. ..	144	8,530	18	8,512	—	8,512	1,218	9·7
	II	.. .. ..	563	8,213	24	8,189	—	8,189	1,227	9·4
May	I	.. .. ..	563	7,559	9	7,550	—	7,550	1,236	8·8
		Total	24,674	6,25,631			20,046	5,38,614	16,805	555·0

STATEMENT II-A

Power flows through Nagarjunasagar as per data supplied by Project Authorities

Period		Demand at Delta	50% Int. flows limited to (2)	Net demand (2)—(3)	Firming up flows	Power flows	Power flows 1,000 Cusecs.
(1)		(2)	(3)	(4)	(5)	(6)	(7)
May	II ..	9·93	—	9·93	—	9·93	7·58
June	I ..	9·38	0·56	8·82	—	8·82	6·73
	II ..	20·51	3·44	17·07	—	17·07	13·00
July	I ..	22·18	14·75	7·43	..	7·43	5·66
	II ..	17·95	17·95	—	3·00	3·00	2·29
Aug.	I ..	19·16	13·82	5·34	—	5·34	4·07
	II ..	16·10	13·71	2·39	0·68	3·07	2·34
Sep.	I ..	15·94	8·35	7·59	—	7·59	5·79
	II ..	15·23	12·11	3·12	—	3·12	2·38
Oct.	I ..	16·13	16·13	—	2·68	2·68	2·04
	II ..	13·23	4·44	8·79	—	8·79	6·70
Nov.	I ..	13·13	1·20	11·93	—	11·93	9·09
	II ..	0·17	0·17	—	2·78	2·78	2·12
Dec.	I ..	0·04	0·04	—	2·83	2·83	2·16
	II ..	0·04	0·04	—	3·05	3·05	2·33
Jan.	I ..	0·54	0·15	0·39	2·47	2·86	2·18
	II ..	0·58	0·09	0·49	2·55	3·04	2·32
Feb.	I ..	3·88	0·03	3·85	—	3·85	2·94
	II ..	3·37	0·01	3·36	—	3·36	2·56
Mar.	I ..	3·87	—	3·87	..	3·87	2·95
	II ..	3·23	0·03	3·20	—	3·20	2·44
Apr.	I ..	4·57	0·02	4·55	—	4·55	3·47
	II ..	4·57	0·02	4·55	—	4·55	3·47
May	I ..	3·92	0·01	3·91	—	3·91	2·98
	Total	217·65	107·07	110·58	20·04	130·62	

STATEMENT III

Scope of using surplus storage capacity at Nagarjunasagar Reservoir for unassured second crop.

All the figures are in T.M.C. Ft.

Years	Gauged yields at Vijaya-wada (a)	Total yields in excess of basic alloca-tions= (2)-1480	Andhra's share of excess yields above N.S.= 40·75% (3) (b)	Net cess yields avail-able for extra second crop= (4)-109 (c)	Yields stored upto 590 from R.L.'s 544 (d)	552·5 (e)	F.R.L. 565 (f)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1894--95	1809	329	134	25	25·0	25	25·0
95—96	2085	605	246	137	122·0	102	70·0
96—97	2320	840	342	233	122·0	102	70·0
97—98	2481	1001	408	299	122·0	102	70·0
98—99	2271	791	322	113	113·0	102	70·0
99—1900	854	—	—	—	—	—	—
1900—01	2577	1097	446	337	122·0	102	70·0
01—02	1822	342	140	31	31·0	31	31·0
02—03	1732	252	102	—	—	—	—
03—04	2952	1472	601	492	122·0	102	70·0
04—05	1456	—	—	—	—	—	—
05—06	1131	—	—	—	—	—	—
06—07	1643	163	66	—	—	—	—
07—08	1911	431	175	66	66·0	66	66·0
08—09	2293	813	332	223	122·0	102	70·0
09—10	7746	266	107	—	—	—	—
10—11	2171	691	281	172	122·0	102	70·0
11—12	1135	—	—	—	—	—	—
12—13	1907	427	174	65	65·0	65	65·0
13—14	1445	—	—	—	—	—	—
14—15	2750	1270	518	409	122·0	102	70·0
15—16	2250	770	313	204	122·0	102	70·0

STATEMENT III—*contd.*

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
16—17	3487	2007	816	707	122·0	102	70·0
17—18	2569	1089	443	834	122·0	102	70·0
18—19	808	—	—	—	—	—	—
19—20	1857	377	153	44	44·0	44	44·0
20—21	1372	—	—	—	—	—	—
21—22	1784	304	123	14	14·0	14	14·0
22—23	1730	250	101	—	—	—	—
23—24	2043	563	229	120	120·0	102	70·0
24—25	1936	456	186	77	77·0	77	70·0
25—26	1819	339	138	29	29·0	29	29·0
26—27	1953	473	193	84	884·0	84	70·0
27—28	2054	574	234	125	122·0	102	70·0
28—29	1901	421	172	63	63·0	63	63·0
29—30	1627	147	60	—	—	—	—
30—31	1927	447	182	73	73·0	73	70·0
31—32	2508	1028	419	310	122·0	102	70·0
32—33	2472	992	404	295	122·0	102	70·0
33—34	2524	1044	426	317	122·0	102	70·0
34—35	1794	314	128	19	19·0	19	19·0
35—36	1600	120	50	—	—	—	—
36—37	1652	172	70	—	—	—	—
37—38	3336	1856	755	646	122·0	102	70·0
38—39	2169	689	281	172	122·0	102	70·0
39—40	1713	233	94	—	—	—	—
40—41	1903	423	172	63	63·0	63	63·0
41—42	1310	—	—	—	—	—	—
42—43	1610	130	53	—	—	—	—
43—44	1700	220	99	—	—	—	—
44—45	2000	520	212	103	103·0	102	70·0
45—46	1491	—	—	—	—	—	—
46—47	2224	744	303	94	122·0	102	70·0

STATEMENT III (*contd*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
47—48	2050	570	232	123	122·0	102	70·0
48—49	1916	436	178	69	69·0	69	69·0
49—50	2056	576	235	126	122·0	102	70·0
50—51	2101	621	253	144	122·0	102	70·0
51—52	1460	—	—	—	—	—	—
52—53	1445	—	—	—	—	—	—
53—54	2496	1016	414	305	122·0	102	70·0
54—55	2011	531	216	107	107·0	102	70·0
55—56	2553	1073	437	328	122·0	102	70·0
56—57	3729	2249	913	804	122·0	102	70·0
57—58	2197	717	292	183	122·0	102	70·0
58—59	2573	1093	446	337	122·0	102	70·0
Totals ..				9121	4334·0	3782	2788·0

		STORED		
I.	Annual Average Excess flows	140	66·7	58·2	43·0
II.	Extra paddy at 20 T.M.C. per lakh of acres. ..		3·33	2·91	2·15
III.	Extra annual revenue at Rs. 7·50 nP. per acre (Rs. lakhs)		25·0	21·7	16·1
IV.	Revenue return on Rs. 7·5 crores which is extra capital cost of N.S. Dam above F.R.L. 544 ..		3·3	2·9	2·1
V.	No. of years when lake fills upto F.R.L. 590 and full extra second crop is possible.		26(40%)	30(46%)	33(51%)
VI.	No. of years when extra second crop is possible partly		18(28%)	14(22%)	11(17%)
VII.	No. of years when no extra second crop is possible		21(32%)	21(32%)	21(32%)
VIII.	Total No. of years analysed		65(100%)	65(100%)	65(100%)

STATEMENT III (*concld*)

Explanations:

(*a*) Figures upto year 1944-45 are those given in 1951 allocations of Krishna waters, and figures for years there onwards are as supplied by Director (H. & S.), C.W. & P.C. (Appendix II-B).

(*b*) Total Andhra's share of waters in excess of 1745 T.M.C. Feet of basic allocations is stated as 53·5 per cent by C.W. & P.C. and out of this 12·75 per cent is located below Nagarjunasagar. Therefore the share above Nagarjunasagar is 53·5—12·75 = 40·75 per cent.

(*c*) Requirements of assured irrigation and power planned at Nagarjunasagar and Srisailam :—

		T.M.C. Feet
I.	Requirements at Nagarjunasagar for	
	(1) R.B.C.	222
	(2) L.B.C.	186
	(3) Delta	111
	(4) Firming up power	20
	(5) Evaporation	16
	(6) Extension on Left Bank Canal	42
	Total	597
II.	Requirements at Srisailam :	
	(1) Irrigation	41
	(2) Evaporation	33
	Total	74
III.	Total requirements for assured intentions =(I)+(II)=	671
IV.	Supplies available at Nagarjunasagar from basic allocations as per C.W. & P.C.'s figures	562
V.	Flows required from excess flows for assured intentions (III)—(IV)=	109

(*d*) R. L. 544 is the maximum reservoir level at Nagarjunasagar for normal assured irrigation in the combined operation of Srisailam and Nagarjunasagar Reservoirs as per Team's method with minimum draw-down level of 510 (Working Table IV).

(*e*) The R.L. 552·5 is the maximum reservoir level in the combined operation of Srisailam and Nagarjunasagar Reservoirs as per Team's method with minimum draw-down level of 520 (Working Table IV.)

(*f*) The R. L. 565 is the maximum reservoir level in the combined operation of Srisailam and Nagarjunasagar Reservoirs as per C.W. & P..C.'s method with minimum drawdown level of R. L. 520, (Working Table III.)

STATEMENT IV

Benefits due to adopting I. & P. Team's method of integrated operation of Srisailam and Nagarjunasagar Reservoirs

1.	F.R.L. of Nagarjunasagar required for normal irrigation (with 75% dependability) as per		
	(*i*) C.W. & P.C.'s method of operation ..	—	R.L. 565·0
	(*ii*) I. & P. Team's method of operation ..	—	R.L. 552·5
2.	Extra capacity above F.R.L. for noramal irrigation upto 590 :		*T.M.C. Feet*
	(*i*) C.W. & .P.C.	—	70
	(*ii*) I. & P. Team	—	102
3.	Average annual excess storage available for extra second crop :		
	(*i*) C.W. & P.C.	—	43·0
	(*ii*) I. & P. Team	—	58·2
4.	Extra average annual utilisation possible in Team's operation=60—44·2=	—	15·8
5.	Extra average annual second paddy possible due to Team's operation at 20 T.M.C.Ft. /lakh acres ..	(lakh acres)	0·76
6.	Extra revenue return on 2nd crop due to Teams' proposals at :		*Rs. Lakhs*
	(*i*) Rs. 7·50 per acre	—	5·7
	(*ii*) Rs. 12·0 per acre	—	9·12
7.	Power in M. W. at 100% L. F. developed as per :	Firm	*Average
	(*i*) C.W. & P.C.	156	312·3
	(*ii*) I&P Team	226	344·3
8.	Extra power generated in M.W., as per Team's proposal	70	32·0
9.	Extra hydro energy generation in million K.W. hours replacing thermal/power at 90% transmissin efficiency	552	250
10.	Savings in Rs. lakhs due to less generation of thermal energy at 0·4 anna per unit	138	62·5
11.	Total annual savings in Rs. lakhs=(6)(ii)+(10)=	147·1	71·6

Note.—*Average power has been worked out on the basis of adequate thermal support enabling full exploitation of hydro energy to the extent of installed capacity of (660 MW) at Srisailam.

CHAPTER V

DESIGN FEATURES

5.0.1. The basis of design of this Project is the Joint Report of 1954 by Andhra and Hyderabad States. The first phase 1956 estimate prepared jointly by the Chief Engineer, Nagarjunasagar Dam and Chief Engineer Incharge of Canals is also based on the 1954 Report with a few modifications in the cost of various items.

5.0.2. There are three main units of this Project, namely, (1) Dam, (2) Right Bank Canal and (3) Left Bank Canal.

5.0.3. The main design features of the Dam and the Canals have been materially changed from those in the 1956 first phase estimate on the basis of which the execution of the Project has taken up. It would appear that before the Project was undertaken the main features of the design were not fully considered.

5.1.1. The dam as originally proposed consisted of three sections (1) masonry portion for spillway and two non-flow masonry sections on right bank and left bank sides, (2) two sections of composite Dam on right and left flanks and, (3) earth Dam on left flank. In the present design the length of masonry dam has been considerably increased, composite Dam sections have been omitted and earthen flanks have been provided on both sides. A comparative statement showing the various design features as originally proposed and as under execution is given below :—

Sl. No.	Description of each item	According to 1956 Oct. estimate. Feet	According to present construction programme. Feet
1.	Spillway dam	1880	1500
2.	Length of right non-over flow section	640	1920
3.	Length of left non-over flow section ..	1380	1360
4.	Length of composite dam right flank ..	3220	Nil
5.	Length of composite dam left flank ..	1740	Nil
6.	Earthern dam left flank	6220	7966 (In 2 reaches)
7.	Earthern dam right flank	Nil	2780
	GRAND TOTAL ..	15080	15526
8.	Spillway gates	27 of 60′ × 30′	24 of 50′ × 40′
9.	River sluices	12 Nos. 6′ × 9′	12 Nos. 5 × 9′
10.	Penstocks	5 Nos. 10′	8 Nos. 16′

It will, thus be seen that almost all the important design features of the Dam have been changed. These changes will materially affect the estimate. The Project Authorities hope that on account of these changes the amount of the estimate will not be affected. In view of the important changes made in the design, the 1956 estimate has become un-realistic. It is, therefore, essential that a revised project estimate should be prepared on the basis of the changes made in the designs at the earliest possible date.

5.2.1. *Spillway Capacity.*—The spillway capacity is one of the most important items in the design of any dam and the safety of a dam depends upon the adequacy of the same. The 1954 Project Report refers to this important question in a very brief manner. The maximum flood discharge had been based by reference to the discharges of river Krishna at Vijayawada Anicut which is about 110 miles downstream of Nagarjunasagar Dam site. The maximum flood discharge has been checked up with Nawab Ali Nawaz Jung Bahadur Formula on the basis of the catchment upto the Dam site. The maximum discharge according to this formula was worked out as 10,88,500 cusecs which, it is stated, according to the probability curve will be of a frequency of one in eighty-two years. The crest spillway has been designed for a discharge of 10,27,350 cusecs; allowing for a discharge of 20,000 cusecs through the river sluices, the total spillway capacity provided is 10,47,350 cusecs. The 1956 Report makes no further reference to the spillway capacity, but provides for a spillway of 1880 feet length with twenty-seven spillway gates of 60′ x 30′ and twelve river sluices of 6′×9′.

5.2.2. In the 1954 Report, on the basis of the data of recorded discharges available at Vijayawada, the highest flood recorded is shown as 10,60,880 cusecs on 7th October, 1903. In that Report at page 4, the highest flood recorded on 7th October, 1903 is also shown as 11.94 lakh cusecs. The same highest flood discharge of 11.94 lakh cusecs is shown in Krishna-Pennar Project Report of 1951, Khosla Committee's Report of 1953 and pamphlet published on the New Krishna Project by Andhra Government.

5.2.3. It appears that when Krishna-Pennar Project was prepared, model experiments were carried out for determining the coefficient of discharge, as the recorded discharges at Vijayawada were based on submerged-weir formula. These model experiments showed that discharges at Vijayawada, as recorded, were less by 6.93 per cent to 28.86 per cent for various heights of the floods. On the basis of this, the high flood discharge for various probabilities will materially increase. In view of these discrepancies, the Team prepared a number of notes and forwarded them to the Project Authorities and the Central Water and Power Commission. The important notes exchanged are at Appendices V-A, B, C, D, E, F, G, and H. During discussions the Project Authorities stated that model experiments that were carried out, were not quite representative and that fresh experiments on three dimensional models were proposed to be carried out to verify the results obtained from the previous model experiments. These should be expedited.

5.2.4. When the detailed designs of various features of the Dam were made, fresh calculations were made and it was estimated that the maximum probable flood of 100 years' frequency at the Dam site would be 11 lakh cusecs and that of 1,000 year frequency 13.85 lakh cusecs. The spillway length was reduced from 1880 feet to 1500 feet and twenty-four bays of 50′ x 40′ and twelve sluices of 5′ x 9′ were provided. The discharging capacity of the spillway and the sluices was worked out as 11,87,468 cusecs which was more than enough for the 100 year flood. The peak discharge of a 1000 year flood of 13.85 lakh cusecs was expected to pass over the spillway with a rise of four feet above F.R.L. thus encroaching on the free board by four feet. The safety of the Dam was checked under this condition and it was found to be structurally safe.

5.2.5. The Team considered that a flood discharge of 13.85 lakh cusecs for 1,000 years' frequency was low. After discussions with the Team, the Central Water and Power Commission have since stated that the peak discharge for a 1,000 years frequency at the Dam site will be 15.31 lakh cusecs. It has been calculated by the Central Water and Power Commission that the same will pass over the spillway with four feet extra flood lift above the F.R.L. When a flood of 13.85 lakh cusecs was taken, no routing was done and now by routing the 15.31 lakh cusecs flood, the same level has been obtained. Thus the standard of safety is being gradually reduced. It has been mentioned by Central Water and Power Commission that their designs of dams allow for 100 year flood to be passed at F.R.L. and that the section of the dam is tested for structural stability for a 1000 years flood. In view of some recent mishaps due to inadequate capacity of spillway provided in some dams in this region, it would not be safe to take any risk in this matter. In this connection the following extracts from "Engineering for Dams" by Creager, Justin and Hinds (1947) would be of interest :—

> "Recently, however, it has been proved by advance studies and a greater accumulation of data, that the probability method is entirely inadequate"....."Thus floods have occurred on rivers which, based on probability studies of prior records of considerable length, would have a frequency not of usually adopted 1,000 to 10,000 years but a frequency of once in millions and even billions of years"....."Hazen recognised this pecularity of floods but because of lack of verifying data, he disregarded this possibility in his analysis of floods except that it should be considered an indication of the necessity of using the most conservative methods. But since that time the phenomenon has been reported so often as to change the possibility to practically a certainty".
>
> And finally "In making use of records of maximum recorded floods on river in a given district to estimate the expected peak discharge at a given place, it must be remembered that what has occured in the past must surely be exceeded in the future."

5.2.6. In this connection, it may further be mentioned that in the Report on the Rampadsagar Project prepared in 1951, on river Godavari which adjoins river Krishna, the following data are given in connection with the spillway capacity :—

Catchment Area	1,21,500	square miles
Maximum ever recorded flood	2·1	million cusecs
Probable 100 year or 1·0 per cent chance flood	2·25	Do
Probable 1,000 year or 0·1 per cent chace flood ..	3·06	Do

These figures were worked out on the basis of the discharge data at Dowleshwaram available upto 1951. Further data have become available. The highest flood recorded on 15th August, 1953 was of the order of three million cusecs. A high flood of the same order again occurred on 17th September, 1959. Thus within a short period a high flood approaching that of 1,000 years' frequency has already been experienced on this river twice. On the basis of these further data the 100 years and 1,000 years frequency flood would far exceed those assumed in the Project. It would not be unreasonable to expect a similar situation arising in the adjoining Krishna valley.

5.2.7. It would be most unwise to take any chances with the safety of a large dam, like the Nagarjunasagar Dam, considering the nature and the magnitude of the risks involved. The Team is of the view that the spillway capacity of this Dam should be designed for a flood of the magnitude of 1,000 years' frequency, at present estimated at 15.31 lakh cusecs, but to be further increased, should the proposed model experiments indicate a higher coefficient of discharge for the Vijayawada Anicut. This capacity should be without encroachment on the free board.

5.2.8. To cater for a flood discharge of 15.31 lakh cusecs, the present spillway capacity can be increased by providing three extra bays which is possible under present stage of construction and by providing forty-four feet high gates instead of forty feet gates. The extra cost involved is about Rs. 35 lakhs. Any additional capacity later found necessary can be provided on the left bank, as it is understood there is a suitable site for a saddle spillway in the Tiger Valley on that bank.

5.2.9. As the Dam is reported to be safe for R.L. 594, the extra flood capacity above R.L. 590 will provide a factor of safety for any flood higher than that of 1,000 years' frequency which in view of the Godavari experience cannot be ruled out.

5.3.0. *Canal Designs.*—There have been material changes in the design features of both the Right Bank and Left Bank Canals with respect to 1954 and 1956 Project estimates.

5.3.1. *Right Bank Canal* :—In the 1954 estimate, lining of the canal was provided for the entire length of 276 miles. In the first phase the canal was to be lined for sixty-two miles. However, when the Project was started, it was decided to omit the lining in the first

phase. While making this change in the 1956 Project estimate the section of the canal was kept the same as provided in the 1954 Project. Both 1954 and 1956 Project estimates are based on a section of 150 feet bed width and twenty feet depth at the head for a discharge of 21,000 cusecs. This design has been changed and the final section of the canal now being adopted is 250 feet bed width and fifteen feet depth at the head. This change in design will not only affect the cost of earth work but also of all the masonry structures etc. Similarly major changes have been made in the flume sections of the canal in rock cutting and the size of the tunnels in the head reach. It is understood that these changes in the portion in which the work is in progress, are made on the basis of comparative economics of various sections etc. The Team suggested to the Project Authorities to prepare revised project estimate for the length of the canal to be constructed in the first phase, so that an overall picture may be available regarding the likely total cost. This revised project estimate was expected to be prepared within three months of June 1959, but it has not yet been received. The Team, therefore, stresses the advisability of finalising this estimate as early as possible.

5.4.1. *Left Bank Canal.*—The design features of the Left Bank Canal have also been considerably changed with respect to the 1956 Project estimate. The Left Bank Canal was originally designed for a final full supply discharge of 11,000 cusecs; now it is being designed for a discharge of 15,000 cusecs at the head. This increased discharge is intended for 3.5 lakh acres of extra irrigation beyond the tail reach. The section of the canal previously adopted as 134′ x 15′ for a discharge of 11,000 cusecs, has now been changed to 95′ x 22.10′ for the discharge of 15,000 cusecs. The 1956 Project estimate is based on a flume section of 54′ x 20′ in deep rock cutting for a discharge of 11,000 cusecs and it is now proposed to have a section of 40′ x 32′ for a discharge of 15,000 cusecs.

5.4.2. The 1956 Project provides twin horse-shoe shaped tunnels at the head, of 24.29′ base width. Now it is proposed to have one tunnel of thirty-two feet diameter horse-shoe section.

5.4.3. The 1956 estimate provides for lining the canal in full bed width and to a depth of five feet only for a length of forty miles. It is now proposed to provide lining for the entire section to carry the 1st phase discharge which can be done by adopting a section of 95′ x 16.5′ and it is expected that the cost of lining will not increase. In view of all these changes the Team suggests that the revised project estimate should be prepared at an early date to see how the over-all cost of the Left Bank Canal will be affected.

5.4.4. The designed full supply discharge of the Left Bank Canal has been increased from 11,000 cusecs to 15,000 cusecs with a view to irrigating about 3.5 lakh acres extra below the tail end of the canal. The 1956 estimate provides for the construction of the head sluice and the tunnel in the head reach for a full supply discharge of 15,000 cusecs. There is no provision for constructing the masonry works to suit the final discharge of 15,000 cusecs but the works are being designed on the basis of full supply discharge of 15,000 cusecs. It has

been stated by the Central Water and Power Commission that there is no alternative source for irrigating additional area on the Left Bank Canal extension and that it will be difficult to remodel the masonry works later on and subsequent additions would cost considerably more than the extra cost of making the works slightly larger now, with which the Team agrees.

5.4.5. The canal section itself is being done for 11,000 cusecs only as the designed section is such that the carrying capacity can be increased to 15,000 cusecs by raising the full supply level and raising the banks and lining the canal, later on.

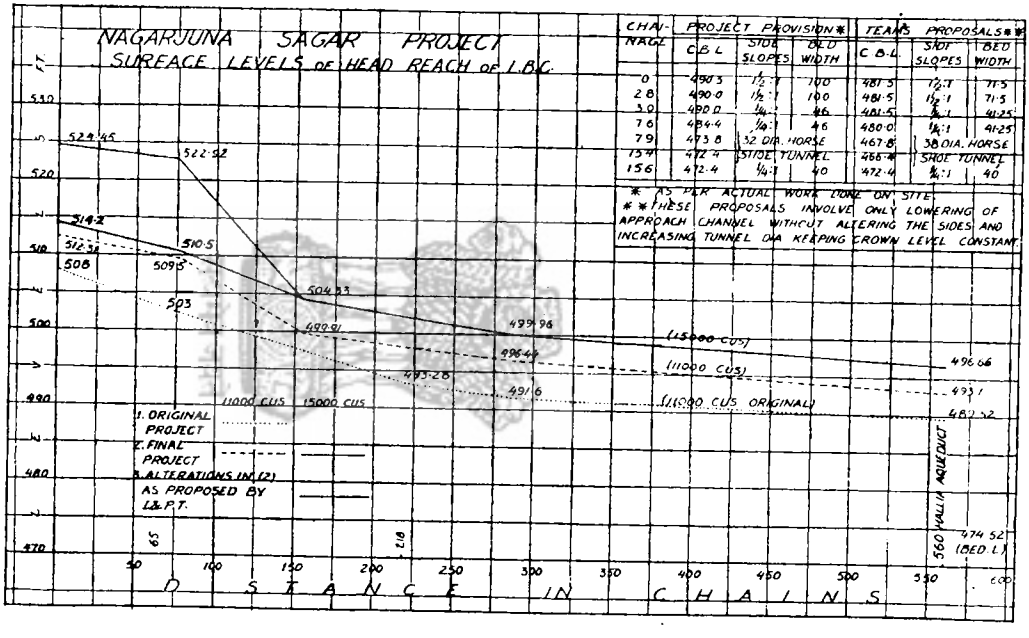
5.4.6. Undoubtedly the State Authorities should have obtained the prior concurrence of the Government of India for constructing the masonry works for a larger capacity. However, in view of the factors stated above, construction of the masonry works to carry the full discharge of 15,000 cusecs would be desirable. The estimated increase in cost, as reported by the Project Authorities to Central Water and Power Commission, will be about Rs. 40 lakhs, for which the State should now take action to obtain the necessary approval of the Government of India.

5.4.7. Apart from the changes in the full supply discharge, the full supply level at the head has been considerably raised. The Project is based on an effective storage above R.L. 500 which is at 2/3rds* of the full supply depth of the canal. The sill level is shown as R.L. 490 and the fully supply depth of the canal in normal section is fifteen feet and in the rock cutting at head twenty feet. This gives the full supply level of the canal between R.L. 505 and 510. The full supply level is not directly shown in any project report.

5.4.8. According to the present design on the basis of which work is in progress, the full supply level at the head has been raised to R.L. 524.58 for a discharge of 15,000 cusecs. For the Right Bank Canal, the full supply level is proposed to be kept at R.L. 511 for the full supply discharge of 21,000 cusecs. Normally it would be desirable to keep the full supply level of the canals on the two banks as close as possible to each other, so that both may make use of the storage under similar conditions.

5.4.9. The full supply level of the Left Bank Canal for a discharge of 15,000 cusecs has risen so high because the flume section has been reduced at the head from the original section of 54′ x 20′ to 40′ x 28.77′ for a discharge of 11,000 cusecs. For a discharge of 15,000 cusecs the depth increases from 28.77 feet to 32 feet. Another very important reason is that instead of twin tunnels giving a water way of 1,100 square feet as provided in the 1956 Project, one tunnel of 850 square feet is now provided in the new design. The velocity in the tunnel has risen from ten feet per second to eighteen feet per second. All these changes have resulted in considerable loss of head (Chart on opposite page). These changes seem to have been made with a view to economising in the cost of construction of the head reach of the

*This is mentioned at page 23 of 1952 Lower Krishna Project which is the basis for 1954 Project so far as Left Bank Canal is concerned



CHAINAGE	PROJECT PROVISION * C.B.L	PROJECT PROVISION * SIDE SLOPES	PROJECT PROVISION * BED WIDTH	TEAMS PROPOSALS ** C.B.L	TEAMS PROPOSALS ** SIDE SLOPES	TEAMS PROPOSALS ** BED WIDTH
0	490.3	1½:1	100	481.5	1½:1	71.5
28	490.0	1½:1	100	481.5	1½:1	71.5
30	490.0	¼:1	46	481.5	¼:1	41.25
76	486.4	¼:1	46	480.0	¼:1	41.25
79	473.8	32 DIA. HORSE		467.8	38 DIA. HORSE	
134	472.4	SIDE TUNNEL		466.4	SHOE TUNNEL	
156	472.4	¼:1	40	472.4	¼:1	40

* AS PER ACTUAL WORK DONE ON SITE.

** THESE PROPOSALS INVOLVE ONLY LOWERING OF APPROACH CHANNEL WITHOUT ALTERING THE SIDES AND INCREASING TUNNEL DIA KEEPING CROWN LEVEL CONSTANT.

canal, but apparently without considering the effect on the working operations of the reservoir to the best advantage for irrigation.

5.4.10. The 1954 Project provides for a minimum draw-down level of 510 in the reservoir. The dead storage level provided is R.L. 490 and the sill level of the two canals is also R.L. 490. The live storage between R.L. 490 and R.L. 510 is 36 T.M.C. Feet. This gives a small carry-over of about sixteen per cent of the live storage in the beginning of the Monsoon. The minimum draw-down level of 510 was sufficient for passing the discharge required in the first fortnight of July in the two canals. The minimum draw-down level is now kept by the Central Water and Power Commission at R.L. 530 *vide* Working Tables supplied by them (Appendix IV and IV-A). The live storage capacity between R.L. 490 to R.L. 530 is 76 T.M.C. Feet. The total live storage of the reservoir from R.L. 490 to 590 is 228 T.M.C. Feet. Thus 33 per cent of the live storage is retained as carry-over with integrated operation of Srisailam and Nagarjunasagar Reservoirs. The surplus storage can be put to a better use for increasing second crop irrigation as explained in Chapter IV.

5.4.11. The minimum draw-down level of R.L. 530 has been necessitated on account of the higher full supply level of the Left Bank Canal, which has been kept at R.L. 524.58 in the new design and due to the provision of a large carry-over in the beginning of the Monsoon season.

5.4.12. The Team has looked into the desirability of lowering the minimum draw-down level of Nagarjunasagar Reservoir from R.L. 530 to R.L. 510 by lowering the full supply level of the Left Bank Canal by ten feet and by reducing the carry-over in the beginning of the Monsoon season with a view to making the best use of the storage capacity. This question has been discussed with the Project Authorities on 25th and 26th March, 1960 and they have expressed that a large carry-over previously proposed, is not necessary and that the draw-down level in normal working can be lowered to R.L. 520 without lowering the full supply level of the Left Bank Canal by ten feet as the demand of the Left Bank Canal in June and first fortnight of July, before the rains set in, can be conveniently supplied with the minimum reservoir level of R.L. 520. In order to have the maximum second crop cultivation in surplus years and to give early supply of water to cotton crop which has been suggested to be encouraged in Chapter X, it was considered that lowering the full supply level of the Left Bank Canal by about ten feet will enable the storage between R.L. 520 and R.L. 510 to be put to a valuable use for sowing early cotton or increasing the second crop cultivation.

5.4.13. There are two alternatives for lowering the full supply level of the Left Bank Canal by ten feet. One alternative would be to increase the size of the tunnel under construction from thirty-two feet diameter to thirty-eight feet diameter and to lower the bed of the flume upstream of the tunnel. The second alternative would be to provide a second tunnel of appropriate size later, when the extension of the Left Bank Canal is undertaken, but to construct suitable approaches

upstream and downstream of the tunnel now. As it will be several years before the Left Bank Canal Extension is constructed, the second alternative appears advisable. The Project Authorities have accepted this. The resulting advantages of lowering the full supply level of the Left Bank Canal will be :—

(*i*) The full supply level of the Left Bank and Right Bank Canals will be close to each other, resulting in both the Canals making use of the storage under similar conditions.

(*ii*) The velocity in the tunnel will decrease from over 18 feet per second to under thirteen feet per second. This will increase the life of the concrete lining of the tunnel considerably.

(*iii*) The minimum operation level will be reduced to R.L. 510 as originally envisaged in the 1954 Project. This will also result on an average in an extra second crop irrigation per annum to the extent of about 42,000 acres (Statement III). This will give an extra revenue of Rs. 3.15 lakhs on the basis of water-cess of Rs. 7.50 per acre and Rs. 5 lakhs on the basis of water-cess of Rs. 12 per acre recommended by the Team.

CHAPTER VI

CONSTRUCTION FEATURES

6.1.1. In the 1956 Project estimate, the Dam is designed to be constructed with coarsed rubble masonry facing the random rubble hearting. The front impervious portion for nine feet thickness will be of 1 : 2½ red cement mortar (red cement of surkhi 1 to 4 of cement) and the rest of 1 : 4 red cement mortar. Concrete has been provided in the toe regions where the stresses exceed twenty tons per square foot and also on the rear face of the spillway portion. It is now proposed to use different mixes of mortar :—

1. For zones where stresses are below 15 tons per square foot.	Mortar 1 : 4.7 Strength of Mortar after end of one year 120 tons per square foot.
2. For zones where stresses are between 15 and 20 tons per square foot.	Mortar 1 : 3.91 Strength 160 tons per square foot.
3. For zones where stresses are more than 20 tons per square foot and for the up-stream face of the dam for 9' depth.	Mortar 1 : 3 Strength 240 tons per square foot.

6.1.2. The concrete originally provided at the toe is now proposed to be substituted with random rubble masonry in 1 : 3 red cement mortar. Due to this change a saving of Rs. 40 lakhs has been shown in the revised estimate. The Project Authorities, however, have since stated that this saving will not be realised in full.

6.2.1. Cement for the Dam is being obtained from Macherla cement factory which is situated at a distance of fourteen miles from the Dam on the right bank. As soon as the work was started, a link road with black top was constructed from Macherla to the Dam site at a cost of about Rs. 14 lakhs. Also, a railway line has been constructed from Macherla to the Dam site at the cost of the Project. The main purpose which this railway line will serve, is to bring cement for the Dam.

6.2.2. The total quantity of cement to be brought is about six lakh tons only. The other materials consisting of machinery parts etc., that will have to be brought by the railway line, will perhaps not be more than one lakh tons which could have been brought by road. The cost of the railway line including the cost of quarters and meter gauge wagons converted for haulage of cement in bulk will be about Rs. 50 lakhs. The railway line has come into operation from the beginning of 1959.

6.2.3. Prior to the construction of the railway line, the cement was being brought by road in bags from Macherla factory on the right bank side to the batching plant on the left bank at a cost of about Rs. 3 per ton. The haulage charges by railway from Macherla to the railway terminus near the Dam will be about Rs. 2.75 per ton exclusive of the depreciation charges on the capital cost of Rs. 50 lakhs. The cement will then have to be transported by road in bulk cement carriers for a distance of three miles by double handling from the railway terminus on the right bank to the batching plant on the left bank which will involve extra cost. Cement silos will have to be constructed at the railway siding at the Dam and also near the batching plant on the left bank.

6.2.4. The distance from the factory to the Dam site being only fourteen miles, the cement could have been conveniently and economically brought in bulk cement carriers by road and double handling of cement at the Dam site could have been avoided. The capital cost on the construction of cement silos at the railway terminus at the Dam also would not have been necessary.

6.2.5. For the purpose of bringing cement by road some improvements to the road surface would have been necessary and a few more bulk cement carriers would have been required. The over-all cost of carriage of cement from the factory to the batching plant would have been less.

6.2.6. It may be mentioned that Rihand Project Authorities are transporting cement by road from a distance of about fifty miles in bulk without any difficulty. The maximum quantity of cement required to be carried daily for Nagarjunasagar Dam will be no more than that being carried at Rihand. All the other machinery at Rihand will also be coming by road.

6.2.7. If economics of carriage of cement by road and railway had been worked out in the beginning, the construction of the railway line costing about Rs. 50 lakhs could have been avoided.

6.2.8. A road bridge has been constructed on the down-stream side of the Dam for communications between the two banks. This bridge has a road width of thirty-eight feet and has cost over Rs. 36 lakhs. The normal width of a highway bridge is twenty-two feet. The extra width of sixteen feet has been provided for two narrow gauge tracks which are not likely to be used now. The normal width of twenty-two feet would have been adequate for all the traffic that is required between the two banks. There was no provision for the road bridge in the 1954 estimate. A provision of Rs. 32 lakhs has since been made for it in 1956 estimate. This will be exceeded by about Rs. 4 lakhs.

6.3. The construction of the Dam is planned in two stages i.e. pre-trestle stage and trestle stage. In the pre-trestle stage, the Dam is proposed to be constructed through labour contractors from bed of the river R.L. 240 to R.L. 320 in the spillway portion and to R.L. 360 in the non-spillway portion on both sides. The total quantity of masonry and concrete to be done in the Dam is about 170 M.C. Feet.

Approximately half the quantity is proposed to be done in the pre-trestle stage and half in the trestle stage. In the pre-trestle stage the Dam is to be raised from the foundations for heights varying from 85 feet to 100 feet. In this stage the stone and mortar will all be lifted by labour contractors by providing scaffolding etc.

6.4.1. There are a number of separate colonies constructed at Nagarjunasagar Dam site. These are :—

(*i*) On the Left Bank (Hill Colony);

(*ii*) Pylon Colony in the Centre;

(*iii*) Vijayapuri Right Bank Colony;

(*iv*) Labour Colony including machinery yard on the upstream side which will be submerged next year;

(*v*) Proposed Lankamattu Colony.

All these colonies are rather scattered far apart. The Team considers that the lay-out of colonies for large Projects should be compact as for as possible so that the expenditure on the services like roads, lighting, water supply, sanitation etc. can be kept down to the minimum.

6.4.2. The work of laying masonry including the supply of stone is let out to contractors on piece-work forms from season to season. All the machinery required in the process of laying masonry, mixing of mortar and quarrying of stone is provided by the Govrnment on suitable terms in contracts. The Team is glad to record that this procedure has been adopted on this large masonry dam instead of letting out the whole work to one big contracting firm. In this method most economical rates can be obtained without the contractors having to invest a large capital in purchasing machinery and plant. As the work is let out from season to season, the contractors have not to allow for any extra margin in their rates for unknown contingencies, which the big contractors have to do in case the entire work, expected to continue for a number of years, is let out on one contract.

6.4.3. For the construction of masonry in the trestle stage, three methods for conveyance of rubble and mortar to Dam site have been considered. These are :—

(1) Ropeway from quarries to left bank of Dam combined with carriage of material by road or railway over the trestle bridge.

(2) Meter gauge railway line from quarries to the left bank of Dam and over the trestle bridge.

(3) Road transport in diesel trucks from quarries to the Dam site and over the trestle bridge.

In all these three alternatives the materials are proposed to be carried over the trestle bridge which will be constructed on the down-stream side, with its top at R.L. 420 over the Dam masonry constructed in the pre-trestle stage. The materials from the trestle bridge will be lifted by seventeen mono-tower cranes erected all along the Dam.

The capital cost involved in purchase of machinery and construction of trestle bridge etc. in all these proposals will be of the order of Rs. 2.5 crores.

6.4.4. The Team has discussed all these alternatives in great detail with the Project Authorities. Originally it was intended to carry the materials by meter gauge railway. Finally, it has, however, been decided to carry the materials by road in diesel trucks from quarries to the Dam site and over the trestle bridge.

6.4.5. It appears that the method of carrying materials by ropeway from the quarries to the left bank of the Dam and then by cableways across the Dam has not been considered in any detail. In recent years three large dams, namely, Vaitarna, Koyna and Rihand have been constructed or are in the process of construction through big contracting firms. On all these three dams, cableways have been used with economy and advantage. In addition aggregates are transported by means of ropeways from quarry to Dam site in the case of Vaitarna and Rihand Dams.

6.4.6. As the capital cost involved in all these proposals is quite considerable, it would have been desirable if global competitive tenders had been invited for different methods of transporting materials so that the best and the most economical method could have been found out. The Project Authorities have stated that the flexibility of working, saving in foreign exchange requirements and saving in capital expenditure due to possibility of contractors providing their own trucks for conveyance of rubble are some of the important factors in favour of road conveyance and these factors have influenced the decision in favour of the road conveyance.

6.5.1. The 1956 Project provides for special tools and plant as under :—

	Gross Provision Rs. lakhs	Depreciation Rs. lakhs	Net Rs.lakhs
1. Dam	500	400	100·00
2. Right Bank Canal	400·76	353	47·76
3. Left Bank Canal	300	255	45.00
TOTAL	1200·76	1,008	192·76

6.5.2 The Project Authorities have procured some machinery from other River Valley Projects and some new machinery has been purchased. At present stage there is a proposal to purchase machinery for the three works as under :—

	Rs. lakhs
1. Dam	500
2. Right Bank Canal	294
3. Left Bank Canal	258

The machinery purchased already for the three units is as under :—

	Rs. lakhs
1. Dam	250
2. Right Bank Canal	185
3. Left Bank Canal	110

In the revised estimate, a saving of Rs. 40 lakhs has been shown on the special tools and plant for the Dam and Rs. 30 lakhs for the Canals. The net provision has thus been reduced from Rs. 192.76 lakhs to Rs. 122.76 lakhs.

6.5.3. The unwritten off expenditure on the completion of the works is likely to be very much more. In the case of the Dam alone where gross expenditure is expected to be about Rs. 500 lakhs, the amount written off to rates as shown in the rate analysis is about Rs. 316 lakhs. Thus on completion of the work there will be a debit of Rs. 184 lakhs standing against a net provision of Rs. 60 lakhs in the revised estimate. It appears unlikely that there will be a saving of Rs. 40 lakhs. The original provision of Rs. 100 lakhs may be retained in the revised estimate.

6.5.4 The Project Authorities prepare quarterly and annual statements indicating performance and efficiency of the machinery employed on the Project and these are put up to the Control Board. In these statements performance of all the machinery purchased is not shown. Only important items, mainly of earth moving machinery, are shown. The performance and efficiency of machinery in the annual statement for the year 1957-58 was worked out on the basis of schedule hours of 4,800 for each of the machines. This meant that the machines would be working for two shifts for 300 days in a year. The performance and efficiency shown in that statement was very poor as the machines were not worked at all for two shifts. For 1958-59 the procedure has been changed and the performance and efficiency of machinery are based on working for one shift for 300 days in a year, *i.e.*, 2,400 hours in a year.

6.5.5. It may be mentioned that the earth moving machinery involves considerable capital cost and on account of shortage of foreign exchange, it is very scarce. It should, therefore, be utilised to the best advantage. The Plant and Machinery Committee has recommended that such machinery should be worked for atleast two shifts. The attempt should be to work such machinery for all the three shifts as far as possible. However, the Project Authorities are working such machinery on the basis of one shift only and even on that basis all the machinery is not working fully.

6.5.6. Lists of earth moving machinery, with cost, already purchased for the Dam, Right Bank Canal and the Left Bank Canal are shown in Statements I-A, I-B and I-C. These have been compiled from the lists supplied to the Team and also from the information made available to the Control Board from time to time. Lists of

earth moving machinery for which performance figures have been supplied are shown in Statements II-A, II-B and II-C. In these statements the actual working hours per machine for the whole year and the number of days for which the machine was available during 1957-58 and 1958-59 are shown. It will be seen that the performance figures are not given for all the machinery. The position is summarised in the table below :—

Sl. No.	Items	Total cost of machinery (Rs.crores)	Cost of earth moving machinery		Cost of earth moving machinery for which performance figures are available and analysed	
			Total (Rs. crores)	percentage over (3)	Total (Rs. crores)	percentage over (4)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	Dam	2·50	1·18	47·2	0·88	74·9
2.	R.B. Canals ..	1·85	1·40	75·8	1·11	78·9
3.	L. B. Canals ..	1·10	0·98	89·2	0·76	76·0

6.5.7. From the figures of performance given in Statements II-A, II-B and II-C it will be seen that the overall efficiency of the earth moving machinery is poor. The overall average working efficiency for the two years 1957-58 and 1958-59 is shown below :—

	1957-58 hours per working day	1957-58 minutes per working day	1958-59 hours per working day	1958-59 minutes per working day
Dam	2	13	3	04
Right Bank Canal	2	11	1	34
Left Bank Canal	2	33	1	07

6.5.8. It is, therefore, reasonable to conclude that the Project Authorities have either too many machines to be fully utilised on existing work, or the state of maintenance and supervision is such that the machines cannot work up to the normal efficiency.

6.5.9. It appears that the hire charges for the machines have been calculated on the basis recommended by the Cost and Rates Committee. The hire charges per hour consist of :—

(*i*) capital depreciation of the machines,
(*ii*) repairs and replacement,
(*iii*) fuel and lubricants, and
(*iv*) labour charges.

The most important item is the depreciation as will be seen from the analysis of hire charges supplied to the Team in the case of four

machines (Appendix VI). In calculating the depreciation per hour the working life of the machines has been assumed on the basis given in the Report of the Plan and Machinery Committee (*i.e.*, 10,000 to 15,000 hours) but this life of the machines as given in that report is based on a reasonable utilisation of the machines per day. Both the Plant and Machinery Committee and the Rates and Cost Committee have recommended atleast two shifts working for such machines.

6.5.10. If, however, a machine works only for a fraction of a shift per day the number of years for which the machine will have to be worked to obtain the full estimated working hours from it, will be very considerable. This is likely to render the machine obsolete owing to the difficulty of procuring spare parts etc. The interest charges will mount up. The full cost of the residual life of the machine cannot be realised. Besides, the operational charges will be higher per unit output, in comparison to the standard charges adopted in raising the debits against works.

6.5.11. In view of all these factors, the Team recommends that the greatest caution should be exercised in purchasing further machinery particularly earth-moving machinery on this Project, until full use of existing machinery can be made. Efforts should be made to work all such machinery for atleast two shifts per working day.

6.5.12. On 26th March, 1960 while discussing the draft Report, the Project Authorities supplied the Team with revised statements of efficiency both for Right Bank and Left Bank Canals (Appendices X and XI). The over-all average working efficiency for the two years 1957-58 and 1958-59 as worked out by the Project Authorities for Canals, is as below :—

	1957-58		1958-59	
	Hours	Minutes	Hours	Minutes
Right Bank Canal	4	23	5	33
Left Bank Canal	3	11	3	30

The figures of actual working hours taken by the Team from the original efficiency statements of the Project Authorities and those supplied by them now practically tally. In this connection it has to be noted that the figures worked out by the Team are based on the statements of performance and efficiency of machinery as given by the Project Authorities to the Control Board from time to time. In these statements the normal basic schedule hours are worked out on the basis of 300 working days per year excepting in the case of some machines which were not available for the whole period as seen from the remarks accompanying such statements.

However, the Project Authorities have now stated that the normal basic period should not be taken as 300 days and that allowance of another 50 days on rough basis should be made for days lost due to rains etc. They have also stated that several machines were not in commission for the period shown under the column of basic

schedule hours in these statements. Consequently the days shown as not available for work due to rains and late commissioning of machines etc. are much more than what were previously taken in their efficiency statements.

The Team is not in a position to verify the correct position at this stage. However, even on the basis of figures worked out by the Project Authorities, it is seen that for available 16 hours (two shifts), the percentage efficiency for the canals works out as follows :—

	1957-58	1958-59
Right Bank Canal	27.5%	34.7%
Left Bank Canal	20.0%	22.0%

The Chief Engineer, Dams, has also stated that similar allowance for rainy days etc. should be made in case of machinery employed on the Dam and that allowance should also be made for strike days etc. which will give a much better picture of the efficiency.

There is considerable scope for improvement, specially by working the machinery for two shifts, which the Project Authorities state, is being attempted now as far as possible.

One of the contributing causes for the low efficiency is the considerable delay that takes place in procuring spare parts due to difficulty of foreign exchange. Normally the time taken for importing the spare parts is ten to twelve months. In some cases the time taken is even two years and more. This difficulty has been noticed by the Team in their study of other projects also. It is suggested that necessary steps should be taken at the highest level to avoid costly and scarce machinery remaining idle for lack of spares.

6.6. The Team is glad to record that the Project staff is working with a fine team spirit.

STATEMENT I—A

Earth Moving Machineries obtained for Nagarjunasagar Dam

Sl. No.	Particulars of the machinery	No.	Amount Rs.
1.	P & H Shovel	4	19,40,000
2.	Marion Shovel	1	6,08,000
3.	Euclid Rear Dumpers	11	25,96,770
4.	Letourneau Rear Dumpers	3	7,79,500
5.	Motorised Scrapers	15	26,85,140
6.	Crawler Dozers	8	8,85,770
7.	Crawler Tractor D. 6	2	2,60,000
8.	Bottom Dumper D.W. 15	1	2,18,400
9.	Allishalmer Tractors	4	47,450
10.	B.M.D. Tractors	6	92,800
11.	Motor Grader	2	1,71,000
12.	Road Rollers	4	1,70,600
13.	Mack Tractor	1	1,47,600
14.	Rippers	2	3,530
15.	D.W. 20 Tractor	1	1,80,950
16.	Fowler Tractor	6	51,000
17.	Sheep Foot Rollers	12	22,000
18.	Kolhring Dumpers..	7	3,50,000
19.	800 Gallon Tankers	2	30,000
20.	Trailer and Tanker	1	1,60,000
21.	Euclid Bottom Dumpers	5	3,26,550
22.	Northwest Shovels	1	52,000
		99	1,17,79,060

STATEMENT I-B

Cost of Earth Moving Machineries obtained fo .Right Bank Canal

Sl. No.	Name of machine (obtained by Purchase)	No. of machine	Cost
1.	N.W. Excavator	1	4,00,000
2.	Euclid Rear Dumpers	15	22,20,800
3.	Motorised Scrapers	8	12,11,000
4.	18/25 'c' Yds. M Scrapers	2	5,21,000
5.	Tractors 190 HP	4	5,42,000
6.	Dozer Tractors 120 HP	3	2,87,000
7.	Cat. D-7 Dozer Tractor	2	2,47,200
8.	A.C. Model C. Tractors	2	71,400
9.	Crawler Tractors, with S.F. Roller	4	1,21,900
10.	A.C. Model C. Tractors with S.F. Roller	3	1,65,600
11.	T.D.-24 Crawler Tractor	1	1,77,900
12.	Cat D-8 Crawler Tractor	2	3,70,000
13.	Cat D-8 Crawler Tractor with S. F. Roller	3	5,13,000
14.	L & T Model L.S.F. Roller	2	1,13,000
15.	Marshall Flat Foot Roller	12	3,90,000
16.	G. Motor Grader	1	67,600
17.	Crawler Tractor 190/HP	4	5,12,400
18.	Tracto Tanker	2	26,900
19.	Ferguson Tractors	2	28,300
20.	Water Tankers	4	59,800
21.	Cat. DW-15 R.T. Tractor	1	1,07,600
22.	Flat Foot Rollefs	4	2,44,000
23.	D.D. S.F. Rollers	1	28,000
24.	Traca M. Crawler Tractor	4	1,28,000
25.	BTD-6 Crawler Tractors	4	1,92,000
26.	Tracto Tankers	6	99,000
27.	A.C.T.S.-360 Scrapers	1	2,50,000
28.	A.C. HD-II C. Tractor	4	5,04,000
29.	B.T.D-6 Tractor	3	93,000

STATEMENT I—B (*concld*)

Sl. No.	Name of Machine (obtained by transfer)	No. of Machine	Cost
30.	N.W. Excavator	1	3,11,000
31.	Euclid '9-BV' Belt Loader..	1	2,00,000
32.	Cat DW Bottom Dumper	10	19,00,000
33.	Euclid Bottom Dumper	3	2,82,700
34.	Foroher Challenger Tractor	2	1,83,800
35.	H.D-15 Crawler Tractor	1	85,300
36.	Heavy S.F. Roller	1	4,10,000
37.	Marshall Road Roller	3	1,20,000
38.	A.B. Road Roller	2	80,000
39.	Warce Motor Grader	2	97,800
40.	Tracto Tankers (Olive)	3	26,300
41.	Tracto Tankers (Olive)	4	17,300
42.	A.B. Dumpers	3	1,80,000
43.	Cat. D.W.—20 B Dumper	2	3,80,000
	TOTAL ..		1,39,66,600

STATEMENT I-C

Earth Moving Machineries obtained for Left Bank Canal

Sl. No.	Name of machine	No.	Cost
1.	Heavy Sheep Foot Roller	2	44,000
2.	Trailer with Tractor	1	31,855
3.	S. 'C' T. Scraper	2	3,95,840
4.	TD-24 Crawler Tractor	1	1,63,100
5.	TD-7 Crawler Tractor	4	4,50,064
6.	Water Tanker	14	53,200
7.	Fordson Major Tractors	6	39,220
8.	Pneumatic D.B. Tractors	1	8,404
9.	BTD-6 Tractors	12	2,42,903
10.	Crank Case Guard	12	1,157
11.	A.C. HD-6B Crawler Tractor	4	1,94,850
12.	Sheep Foot Roller	12	72,000
13.	H.D.D.S. Roller	4	26,000
14.	Lima Shovel	1	6,12,500
15.	Lima Shovel	2	11,17,200
16.	Rear Dumper	3	2,56,812
17.	Water Tanker	8	39,600
18.	H.D-11. Crawler Tractor	2	1,91,896
19.	A.C. T.S.—360 Scraper	5	12,90,000
20.	H.D-21. C. Tractor	3	6,74,652
21.	D-8 Tractor	1	2,17,231
22.	D-7 Tractor	2	3,10,342
23.	H.D-16 Converter	6	9,64,242
24.	H.D-16 C. Tractor	3	5,05,050
25.	A. Grader	1	87,000
26.	W-2 Foot Roller	2	22,600
27.	TS-360 Scraper	1	2,59,233
28.	H.D-6B. D.C. Tractor	3	1,65,579
29.	H.D-16 AC Tractor	2	2,81,962

STATEMENT I-C (*concld*)

Sl. No.	Name of machine	No.	Cost
30.	Bulldozer	2	48,112
31.	Z.M. Road Roller..	2	54,126
32.	A. Grader	1	96,455
33.	L & T.S.F. Roller	4	39,600
34.	H.D.D. Roller	4	39,600
35.	H.S.F. Roller	4	88,000
36.	I.H.C. Tractor	1	31,000
	TOTAL ..		91,15,385
	(*Obtained by transfer*)		
37.	D. Roadster Scrapers	2	1,35,262
38.	D.W. 10 Wagon with Tractor	1	75,000
39.	D. 8 Caterpillar Tractor with Dozer	2	2,53,685
40.	T.D. 24 Tractors	2	2,48,953
	GRAND TOTAL ..		98,28,285

STATEMENT II-A

**Nagarjunasagar Dam—Average Working Efficiency of the Machineries*

Sl. No.	Name of machinery	1957-58					1958-59				
		No.	Actual working hours	No. of working days	Average working hours per day- 4(*i*)/ 4(*ii*).	Cost of the machine	No.	Actual working hours	No. of working days	Average working hours per day- 8(*i*)/ 8(*ii*).	Cost of the machine
1	2	3	4(*i*)	4(*ii*)	5	6	7	8(*i*)	8(*ii*)	9	10
1.	D-7 Bull Dozer 4T/389	1	—	300	—	78,668	1	—	300	—	78,668
2.	D-8 Bull Dozer 14 A/484 ..	1	980	300	3—16	—	—	—	—	—	—
3.	D-8 Bull Dozer	3	4085	800	5—50	4,50,000	3	3205	900	3—34	4,50,000
4.	D-8 Bull Dozer 14 A/1625 ..	1	2455	300	8—11	1,01,383	1	1893	300	6—18	1,01,383
5.	TD-24 Bull Dozer	2	3092	600	5—09	3,00,000	2	1693	600	2—50	3,00,000
6.	TD-24 Bull Dozer TD-24/9484..	1	1598	300	5—19	96,912	1	902	300	3—00	96,912
7.	Allis chalmer HD-16 Dozer ..	1	572	300	1—54	90,226	1	565	300	1—53	90,226
8.	A.C. Scrapers	2	2904	600	4—50	2,50,000	2	1246	600	2—04	2,50,000
9.	C-Roadster Scraper	4	4195	1200	3—30	7,00,000	—	—	—	—	—
10.	Euclid Scraper	4	4062	1600	3—23	7,00,000	4	2972	1200	2—28	7,00,000
11.	Euclid Scraper	1	761	300	2—32	1,75,000	1	1130	300	3—46	1,75,000
12.	DW-15. Scraper 70 C/551 ..	1	1386	300	4—37	94,204	1	973	300	3—15	94,204

13.	DW-Scraper 70 C/159	1	1316	300	4—23	96,075	1	911	300	3—02	96,075
14.	Euclid Scraper B-21	1	1223	300	4—05	1,03,231	1	1142	300	3—48	1,03,231
15.	Eluclid Scraper B-213	1	1290	300	4—18	94,676	1	1206	300	4—01	94,676
16.	Motor Grader	1	355	300	1—11	81,000	1	193	300	0—39	81,000
17.	Motor Grader 8T/15532 ..	1	768	300	2—34	66,946	1	456	300	1—31	66,946
18.	Formall Tractor	4	4184	1200	3—30	54,400	—	—	—	—	—
19.	D-6. Tractor	—	—	—	—	—	2	1429	550	2—36	2,60,000
20.	Euclid Dumper	11	3995	3300	1—13	23,98,000	11	13301	3300	4—02	23,98,000
21.	Fowler Tractor	6	1212	1800	0—40	60,000	—	—	—	—	—
22.	L. Scraper	—	—	—	—	—	4	2073	1200	1—44	7,16,037
23.	Marian Shovel	—	—	—	—	—	1	794	300	2—39	6,08,900
24.	Allis chalmer Tractor	1	92	300	0—18	13,600	—	—	—	—	—
25.	D-15 Bottom Dumper	1	173	300	0—35	1,61,000	1	838	300	2—48	1,61,000
26.	Kolhring Dumper	7	599	2100	0—17	2,17,000	—	—	—	—	—
27.	P & H Shovel	2	238	600	0—24	8,40,000	3	3176	900	3—32	12,60,000
28.	Let. Dumper	3	151	900	0—30	6,40,000	3	3956	900	4—24	6,40,000
29.	D.W. 20 Tractor	1	10	300	0—02	1,55,000	—	—	—	—	—
30.	Harmon Shovel	—	—	—	—	—	1	9	300	0—02	—
	TOTAL ..	63	41696	18800		80,17,321	48	44072	14350		88,22,258

Average per machine per day $= \frac{41696}{18800}$ 2 = hrs. 13 min. $= \frac{44072}{14350}$ = 3 hrs. 4 min.

NOTE:— Some of the machines were not available for the whole year. The machine-days would be $63 \times 300 = 18900$, but some units were not available for 100 days, hence 18800.

* Data obtained from Agenda of XIX Meeting of Control Board

STATEMENT II-B

Working Efficiency of Machines at Nagarjunasagar Project Right Bank Canal

No.	Name of machine	1957-58					1958-59				
		No.	Actual working hours (*a*)	No. of working days	Average working hours per day- 4(*i*)/ 4(*ii*).	Cost of the machine	No.	Actual working hours	No. of working days	Average working hours per day- 8(*i*)/ 8(*ii*).	Cost of the machine
1	2	3	4(*i*)	4(*ii*)	5	6	7	8(*i*)	8(*ii*)	9	10
1.	North West Excavator Model 80-D-No. I	1	744	300	2—29	3,97,200	1	627	300	2—05	3,97,200
2.	North West Excavator Model 80-D-No.II	1	—	150	—	2,09,202	1	65	300	0—13	2,09,202
3.	Euclid Rear Dumpers	7	2968	2100	1—25	9,85,600	15	5810	4550	1—32	22,20,800
4.	Euclid Rear Dumpers	8	—	1800	—	12,35,200					
5.	Cat D.W. 20 Bottom Dumpers	10	—	2250	—	18,00,000	15	2106	4500	0—29	24,42,711
6.	Euclid B 5 F.D. Bottom Dumpers	3	—	225	—	2,82,711					
7.	Motorised Scrapers	10	9869	2500	3—52	17,50,855	10	8691	3000	3—04	17,50,855
8.	I. Crawler Tractors	28	23381	6675	3—23	28,34,739	35	23978	11100	2—45	32,35,564
9.	Cater-pillar D. 7 Tractor	2	2278	380	6—00	2,47,161	—	—	—	—	—
10.	Fowler Challenger Tractor	2	—	600	—	1,83,728	2	244	600	0—24	1,83,728
11.	Cat. Tractor hauling unit	1	293	150	1—57	1,03,458	—	—	—	—	—
12.	Euclid 9-B.V Belt Loader	—	—	—	—	—	1	283	300	0—56	2,00,000
13.	Hydraulic Dozers	—	—	—	—	—	4	356	1200	0—18	5,08,700
	TOTAL	73	39443	18,030		1,01,92,266	89	42160	26700		1,11,48,760

Average working efficiency of the machinery per day. $= \frac{39443}{18030} =$ Hours 2 Min. 11

$= \frac{42,160}{26,700} =$ Hour 1 Min. 34

(*a*) No. of working days is based on the basic schedule of hours shown in the annual statement for 1957-58 indicating performance and efficiency of machinery as given in the Agenda for XIX Meeting of Nagarjunasagar Control Board held on 18-10-58 and quarterly statement for 1958-59 supplied by the Project Authorities.

STATEMENT II-C

Working Efficiency of the Machineries at Nagarjunasagar Dam—Left Bank Canal

No.	Name of machine	1957-58					1958-59				
		No.	Actual working hours	No. of working days	Average working hours per day- 4(*i*)/ 4(*ii*).	Cost of machine	No.	Actual working hours	No. of working days	Average working hours per day- 8(*i*)/ 8(*ii*).	Cost of the machine.
1	2	3	4(*i*)	4(*ii*)	5	6	7	8(*i*)	8(*ii*)	9	10
1.	Caterpillar D-8 Tractors ..	2	754	600	1—16	1,26,848	2	672	600	1—07	1,26,848
2.	T. D-24 Tractors	2	368	600	0—37	1,24,476	2	548	600	0—55	1,24,476
3.	I.H. BTD-6 Tractors	9	6804	2700	2—31	22,491	9	5156	900	1—55	22,491
4.	Fordson Major Tractors ..	6	8118	1800	4—09	9,246	6	1596	1200	0—53	9,246
5.	David Brown Tractors	1		300	4—24	84,043	1	539	300	1—48	84,043
6.	Zettle Major D. Road Roller	2	1952	600	3—15	27,467	8	4568	2400	1—54	1,09,868
7.	'C' Model Scrapers	4	1828	1200	1—31	1,75,000	4	2224	1200	3—11	1,75,000
8.	C. D-7 Tractor	2	334	100	3—20	1,28,000	2	922	600	1—32	1,28,000
9.	Bull dozer H.D. 21						1	64	300	0—13	1,27,175
10.	A.C.T.S. 360 Scrapers ..						5	2285	1500	1—31	12,90,000
11.	A.C.H. D-6 Tractor						2	945	600	1—35	1,10,386
12.	A.C.H.D.-16 Tractor						5	978	1500	0—39	48,112

STATEMENT II-C—(*concld*)

1	2	3	4(*i*)	4(*ii*)	5	6	7	8(*i*)	8(*ii*)	9	10
13.	A.C.H.D.-11 Tractor						2	1040	600	1—44	1,91,896
14.	Scrapers 18—C. yds.						5	1325	1500	0—53	12,96,165
15.	Bull Dozers						3	585	900	0—39	3,81,526
16.	Medium Size Crawler Tractor						3	471	900	0—31	3,60,000
17.	Small Size Crawler Tractor ..						4	648	1200	0—32	2,00,000
18.	Adams Motor Graders ..						2	248	600	0—25	1,74,000
19.	D. 8 Bull Dozer						3	730	900	0—48	3,81,526
20.	D. 7 Bull Dozer						5	739	1500	0—29	6,35,875
21.	Lima Shovel Excavator						1	41	300	0—08	5,58,500
22.	Rear Dumpers						4	169	1200	0—09	10,27,248
	TOTAL	28	20158	7900		6,97,571	79	26493	23700		75,62,381

Average working efficiency of the machinery per day. $= \frac{20158}{7900}$ = 2 hrs. 33 mins, $= \frac{26493}{23700}$ = 1 hr. 7 mins,

CHAPTER VII

PHASING OF CONSTRUCTION PROGRAMME

7.1. The first phase of this Project was accepted in the Inter-State Conference held under the auspices of the Planning Commission on 24th February, 1955 and the preliminary work on this project was started in 1955-56. The first phase project estimate of 1956 provides for the completion of the same in 1963-64. The financial forecast has been prepared on this basis. This financial forecast visualises the expenditure on this Project as under :—

		Rs. crores
(1) First Five Year Plan	..	1.11
(2) Second Five Year Plan	..	57.40
(3) Third Five Year Plan	..	28.06
TOTAL :	..	86.57

7.2.1. The expenditure incurred in First Five Year Plan and that expected during the Second Five Year Plan will be as under :—

		Rs. crores
(1) First Five Year Plan	..	1.09
(2) Second Five Year Plan	..	37.98
TOTAL :	..	39.07

On account of the reduced allotment for the Second Five Year Plan, the construction programme has had to be modified and the Project is now expected to be completed not before 1965-66. The revised financial forecast has been based on this assumption.

7.2.2. The total quantity of the masonry in the Dam to be done in the approved First Phase is 160 M.C. Feet. The construction of the Dam has been divided into two stages namely pre-trestle stage and trestle stage. The work of pre-trestle stage will consist of raising the Dam to R.L. 320 in the spillway portion and to R.L. 360 in the non-spillway portion. The work in the trestle stage is expected to be started in June, 1961. The quantity of masonry to be done in the pre-trestle stage is nearly half or about 81 M. C. Feet. of this quantity 36 M. C. Feet have been completed to end of March, 1960. Thus the quantity remaining to be done in the pre-trestle stage is about 45 M.C.Feet. The average output will have, therefore, to be about 3.0 M.C.Feet a month. As the work proceeds, the lift for the masonry will steadily increase. It is, therefore, likely that the trestle work will be delayed for some time.

7.2.3. In order to complete the remaining quantity of masonry within the Third Plan, the average annual output of masonry from now onwards will have to be 24 M.C. Feet. Considering the limited space that will be available during the last 2 years specially, the peak out-turn will have to be 30 M. C. Feet per year, which will have to be aimed at for the next 3 years. This can be attained with concentrated effort and well organised system. All arrangements should be made to achieve this progress.

7.3.1. The construction of the masonry of the Dam will be the controlling factor in the completion of the Project. Because of the high level of the take-off of Canals, irrigation benefits will start accruing on them only when the Dam is nearing completion. There fore, in allocating funds for the various units of work on this Project, the Dam should receive preference.

7.3.2. Any delay in the completion of the Project beyond Third Five Year Plan will entail further extra burden on the Project on account of interest charges and overheads. The financial return which is already low will be further affected.

CHAPTER VIII

POWER DEVELOPMENT

8.1.1. The 1954 Project envisaged development of firm power of 75,000 KW at sixty percent load factor. In addition to this, a large amount of secondary power was to be produced during Monsoon months of July to October. For this purpose, an installed capacity of 1,00,000 KW consisting of five units of 20,000 KW each has been provided. In the first phase estimate of that Project, a provision of Rs. 20 lakhs has been made for the installation of five penstocks of ten feet diameter each and other ancillary civil works.

8.1.2. The power potential is based on Working Table No. IV in 1954 Project. It is mainly determined by the demand for second crop irrigation in the Delta for which water is needed in non-Monsoon months. The Monsoon months discharges are quite ample. The firm power potential is roughly based on a discharge of about 2,250 cusecs flowing below the Dam. The demand Table No. II in 1954 Project shows practically no flows of water below the Dam for Delta irrigation for five fortnights from November II to January II. For firming up power during these fortnights, about 15 T.M.C. Feet of water are provided to be let down.

8.1.3. The first phase estimate prepared in 1956 does not contemplate any generation of power. For exploiting the power potential later on, there is a provision of Rs. 50 lakhs for the installation of eight penstocks of fourteen feet diameter and other ancillary civil works to enable an installation by stages of eight generating units of 37.5 MW each. This provision is ultimately to be debited to the hydel scheme.

8.2.1. The scope of firm power potential from Nagarjunasagar is dependent on the flows let down from Nagarjunasagar for second crop irrigation in the Delta. As mentioned in Chapter II—"Availability of Water", the Project Authorities have now provided 20 T.M.C. Feet of extra water to be let down for firming up power, in addition to the flows required for irrigation in the Delta. The Team has adopted this figure in working out the power potential in Working Tables No. III and IV. On this basis, the firm power at 100 per cent load factor works out to about 45,000 KW.

8.2.2. In their Memorandum of November, 1958 on 'Number of Penstocks' the Central Water and Power Commission have shown firm power of 80,000 KW for Nagarjunasagar. For this purpose, 56 T.M.C. Feet of extra water have been provided for firming up power. As mentioned in Chapter II—"Availability of Water", extra water is not available beyond 20 T.M.C. Feet for firming up power. Even on the basis of seventy-five per cent dependability, there would be a shortage of 17 T.M.C. Feet in effecting the assured irrigation as planned.

8.2.3. The figures of demand for irrigation and firming up power given by the Project Authorities on the basis of which Working

Tables No. III and IV have been prepared, have since been accepted by the Central Water and Power Commission. According to these Tables, the power potential in the different months varies from about 45,000 KW to about 2,50,000 KW at 100 per cent load factor.

8.2.4. It is now proposed by the Project Authorities to provide eight penstocks of sixteen feet diameter with eventual installed capacity of 400,000 KW. In justification of this, the Central Water and Power Commission have stated as under :

> "According to the working tables prepared by this Commission the power generation at Nagarjunasagar Power Station will vary from 60,000 KW to about 2,46,000 KW both at 100 per cent load factor. Eight penstocks openings of the 16 ft. diameter have been provided in the present designs taking into account all possible eventualities and the possibility that Nagarjunasagar Station may have to operate at very low load factor of the order of even 25 per cent in conjunction with future base load nuclear and thermal stations. In regard to penstocks openings at dam sites, it is very important to allow liberal provisions wherever it could be easily arranged.
>
> It may also be mentioned that, in order to reduce the initial investment on penstocks, a special arrangement is proposed to be adopted for their layout. If the penstocks are embedded throughout the body of the dam in the conventional manner, the total length of each penstock would be about 315 feet, requiring a total of 2,700 tons of steel which, at the rate of Rs. 2,500 per ton, would cost about Rs. 67.5 lakhs. In the design proposed, the penstocks will be carried out horizontally through the dam and ended just at the downstream face of the dam initially and the length for each penstock in this case being about 132 feet requiring a total of only 1,190 tons of steel which would cost about Rs. 29.75 lakhs. In this alternative, the remaining length of penstocks can be added as and when generating units are installed in the power station. It would thus be seen that whereas trying to cater for all future contingencies and possibilities, as stated above, the initial expenditure on the eight penstocks is being restricted to the minimum possible."

To utilise eventually the potentials of power at Nagarjunasagar for peaking, the present provision for embedding in the masonry of the Dam eight penstocks of sixteen feet diameter is in order.

8.3.1. In the first phase, the provision has been made for irrigation of 1.5 lakh acres of second crop in the Delta and 1.2 lakh acres on the Left Bank Canal. In Chapter III—'Feasibility for First Phase Project', it has been explained that there will be no water for second crop with F.R.L. 525 provided in the first phase estimate. In that Chapter, the Team has suggested that the full masonry of the Dam should be completed in the first phase and the installation of the gates may be deferred to the final phase. This will enable the water to be

stored to F.R.L. 546. From Table No. I-B i.e., with F.R.L. at 546, it will be seen that power potential in the first phase, in different fortnights, will vary from about 40,000 KW to 2,30,000 KW both at 100 per cent load factor. Extending the scope of the first phase of the Project to completion of the full masonry of the Dam will thus create a firm hydro-power potential of 100 MW at commercial load factor of 58 per cent. This potential admits of profitable exploitation by tieing it to adjacent load centres and power stations in the area.

8.3.2. Although no provision is made in the first phase of the Project for producing hydro-power at the Nagarjunasagar Dam, exploitation of the Hydro-power potential created by the first phase Dam construction simultaneously with the progress of those constructions can be justified from several considerations. Provision is being made, in any case, of Rs. 50 lakhs in the first phase estimate for embedding eight 16 feet diameter penstocks in the masonry of the Dam. The Team estimates that an additional provision of Rs. 4 crores would enable the construction of a complete Power House at the Dam with an installed capacity of two 50 MW hydro-generating sets and necessary 132 KV step-up transformers, switchgear and auxiliary power house equipment.

8.3.3. From Working Table No. I-B showing operation of Nagarjunasagar Reservoir by itself in a seventy-five per cent dependable year, before Srisailam Reservoir is constructed and integrated operation of Nagarjunasagar and Srisailam Reservoirs is possible, it will be noted that energy potential of the Nagarjunasagar Dam Power House is 614 million KW hours in a year. An installation of 100 MW (two units of 50 MW each) generating capacity in the first instance would establish a firm generating capacity of 100 MW that can operate at 58 per cent load factor generating 507 million KW hours in a year. The balance of the energy potential i.e. 107 million KW hours can be availed of when more generating capacity is installed at later stages of development.

8.3.4. The 100 MW hydro-installation can generate power very economically as the incremental capital cost for the hydro-plant is Rs. 400 per KW; thermal power plant anywhere in the region will cost more than twice this amount per KW for installation; in addition, there will be extra expenses for providing coal as fuel.

8.3.5. All the resources now provided at Nagarjunasagar for building the Dam i.e., communications, construction plant and technical personnel may be availed of to economically construct the power house at present and to purchase and install the hydro-power plant. Development of Nagarjunasagar hydro-power potential at this time as a part of the first phase of Nagarjunasagar will help to provide 100 MW of very economical power capacity in this region at the earliest practicable. There is great shortage of power capacity in the region which is inhibiting both medium and large scale industrial developments. If it is found possible to finance the Nagarjunasagar hydro-power development of 100 MW at this stage at an estimated

cost of Rs. 4 crores, it will permit phasing to later stages, building relatively costlier thermal power capacity or exploiting other hydro-power potential; in the latter case funds will be necessary for civil works (Dams) as well as for the Hydro Power Station. The Team recommends that consideration be given for according high priority to the power development at Nagarjunasagar in the first phase, as it will not only mitigate the power shortage but will also improve the financial forecasts of Nagarjunasagar Project which would otherwise receive revenues from irrigation services only.

8.3.6. To utilise the power quickly, 132 KV transmission lines will be necessary to connect Nagarjunasagar Power Station to one or more load centres. Transmission circuits may be planned, in the first instance, to Vijayawada and Hyderabad. These lines will also serve to interconnect Nagarjunasagar Hydro Power Station to existing power stations in the region as Hydro at Machkund and thermal power stations now linked to Hyderabad and Vijayawada. The total installed capacity in those power stations is expected to be of the order of 200 MW in 1960-61. When Nagarjunasagar Power Station is interconnected to this system, its operation can be co-ordinated with operation of other stations in the grid so that in the early stages, no additional capacity need be installed at Nagarjunasagar to serve as a spare set.

8.3.7. The Team, therefore, recommends the following phasing of the development of the power potential at Nagarjunasagar so that the power benefits may be quickly realised and revenues from the sale of power may help to improve the remunerative aspects of the whole Project :—

1. Complete the construction of the Power House at Nagarjunasagar Dam with an installed capacity of 100 MW simultaneously with the completion of the first stage of the Dam i.e., storing water upto R.L. 546 by about June, 1965. This is estimated to cost Rs. 4 crores.
2. Construct 132 KV lines to transmit power from Nagarjunasagar to load centres at Vijayawada and Hyderabad. Another Rs. 4 crores would suffice to construct main and distribution lines and sub-station facilities required to deliver Nagarjunasagar Power at the main load centres.

Additional expenditure to develop 100 MW power at Nagarjunasagar and distribute it, may, therefore, amount to Rs. 8 crores or Rs. 800 per KW. This will cost approximately Rs. 80 per KW year at the main receiving and sub-stations. If bulk power is priced at the receiving stations at 3.25 nP per KW hours, at which it can be readily marketed at present, the gross revenue that can be realised will be Rs. 171 per KW year at a load factor of sixty per cent Allowing twelve per cent overall losses, the net revenue from bulk power sales from Nagarjunasagar will amount to Rs. 150—80 = Rs. 70 per KW year or Rs. 70 lakhs per annum. This will help to materially augment the total earnings from the first phase Nagarjunasagar Project.

CHAPTER IX

CONSTRUCTION COSTS

9.1.1. The 1954 Joint Projects Report by Andhra and Hyderabad States for Nandikonda Projects provided Rs. 85.5 crores for the first phase. Before the project was accepted by the Government of India, the report was discussed by the two Chief Engineers for Irrigation of Andhra and Hyderabad States with the Technical Committee for the Optimum Utilisation of Krishna and Godavari Waters, in September, 1954. During the course of discussions it was suggested by the Technical Committee that scheme with cost limited to Rs. 75 crores, had a chance of being accepted. As a result of these discussions, the two Chief Engineers for Irrigation, Andhra and Hyderabad States indicated in their joint D.O. letter No. 135, Camp New Delhi dated the 4th September, 1954, addressed to the Chairman, Central Water and Power Commission, (Appendix VII), the possibilities of reduction in the estimate and calculated approximately that the first phase plan will cost Rs. 75.08 crores and will irrigate 23.6 lakh acres and yield a return of 5.05 per cent on the net capital.

9.1.2. This first phase plan was accepted in the Inter-State Conference held under the auspices of the Planning Commission on 24th February; 1955, (Minutes of the Conference—Appendix VII).

9.1.3. Soon after the Project was started, it was observed that the figure of Rs. 75.08 crores for the first phase could not be adhered to, nor could the financial return of 5.05 per cent or irrigation benefits of 23.6 lakh acres be realised. It would appear that the figures of estimated cost and the percentage financial return given at the time of commencement of the Project was not realistic.

9.1.4. The Planning Commission called for the first phase estimate and financial forecast in September, 1955. A fresh estimate for the first phase was prepared in October 1956 and amounted to Rs. 86.57 crores. It provided irrigation for 20.60 lakh acres against 23.6 lakh acres in the first rough estimate of Rs. 75.08 crores. The financial return expected on the basis of 4.5 per cent simple interest on sum at charge after ten years from the date of completion of project in 1956 estimate is shown 2.64 per cent. It may be mentioned that this estimate has also not been prepared on the basis of proposed changes in the main features of the project designs but is more or less based on 1954 project estimate.

9.1.5. On account of increase in cost of cement and oils, this estimate has been further revised to Rs. 91.12 crores. This revised estimate had also not been prepared on the basis of changes made in the designs etc. This estimate has since been approved by the Nagarjunasagar Control Board in their XX Meeting held on 30th December, 1958 (Appendix IX). The statement accompanying the Appendix shows excesses and savings with respect to October, 1956 estimate. No estimate has yet received sanction of the Government of India.

9.2.1. As explained in Chapter V—"Design Features", there have been very material changes in the main design features of the Project and unless a proper project estimate is prepared incorporating all the changes, the present estimate of Rs. 91.12 crores cannot be considered to be a realistic one. Both the Chief Engineers of Dam and Canals had agreed in the course of discussions held with the Team on 8—10th February, 1959 to prepare fresh estimates incorporating the major changes in about three months but these estimates have not yet been received by the Team.

Anticipated excesses and savings on dam.—The dam is now expected to cost as under :—

	Rs. crores
1956 Project estimate	33·84
Probable excesses	2·54
Total	36·38

The probable net excess of Rs. 2.54 crores is arrived at as under :—

	Rs. lakhs
Excesses	
Extra cost of cement	331·50
Extra cost of Steel	21·00
Extra Cost of P.O. Ls.	12·00
Excess on account of re-allocation of monuments	6·00
Total	370·50
Savings	
De-watering and Coffer dams	20·00
Railway Lines	10·00
Replacement of concrete by 1:3 cement mortar masonry	40·00
Reduction in radius of spillway	6·00
Procurement of surplus machinery from other projects	40·00
Total	116·40
Net excess	254·10

The two major items of this work are masonry dam and earthen flanks.

The estimated cost of masonry dam as per 1956 estimate is as under :—

	Rs. lakhs
1. Spillway	1,387·00
2. Gravity dam	890·00
Total	2,277·00

9.2.2. The cost of these works will be affected by the changes which have been made in the lengths of both spillway and gravity dam referred to in Chapter V. The Project Authorities do not expect any excess due to increased length of masonry dam, as it is expected that the excess will be more than offset by the savings of masonry in foundation of the dam in the river portion. This can only be ascertained after the revised estimate, incorporating all the alterations made in the designs, is prepared.

9.2.3. The excess due to increased cost of cement is expected to be Rs. 331.50 lakhs. The rate for cement adopted in 1956 estimate is Rs. 65 per ton. This rate consists of supply of cement at Rs. 47.50 per ton at Macherla factory and the remaining amount of Rs. 17.50 was to cover excise duty, sales-tax, transport, and other incidentals etc. Before the project was started, a licence for installing the cement factory at Macherla was given to M/s Ram Krishna & Sons, and under an agreement between this company, the cement was to be supplied at Rs. 47.50 per ton ex-factory. This position has radically altered due to the State Trading Corporation being entrusted with the work of sale of cement, after the project was started. As a result, apart from the increase in the retention of ex-factory price and excise duty the Project has been called upon to bear along with the other consumers additional charges of Rs. 15 per ton on account of average railway freight and Rs. 10.36 per ton as State Trading Corporation's profit and selling agency charges. The present cost of cement in bulk works out to Rs. 96.86 per ton against Rs. 47.5 per ton. The purchase of Cement through the State Trading Corporation has involved considerable burden on the Project, which was not anticipated, when the project estimate was prepared.

9.2.4. The question of likely excesses and savings on the Dam has been gone into with the Project Authorities. A note has been furnished by the Project Authorities showing the comparison of the rate for masonry provided in the project estimate and the rate as per present working. It is seen from that note that practically no excesses are expected on these rates excepting those due to the increase in rate of cement.

9.2.5. The break down of the rate per unit for cement masonry 1 : 3.91 as per rate analysis for present working is as under :—

Rubble	24·68
Laying and curing	20·76
Sand	8·93
Cement at the Project rate of Rs. 65 per ton	24·70
Ad-mixtures consisting of Surkhi and acrosine	4·86
Manufacture of mortar	2·94
Transport of Mortar	2·00
Ancillaries and incidentals consisting of hutting, maintenance of townships and services, labour amenities, workman compensation, quarter, light, water supply, ordinary supervisory and construction staff, consultatants' fee and laboratory charges	13·50
TOTAL	102·37
Lift charges for pre-trestle stage upto R.L. 360	10·00
TOTAL	112·37

9.2.6. The estimated rate is Rs. 113 per unit of 100 C. Feet of masonry. While working out the rates, sufficient allowance has not been made for depreciation in the rates of items where machinery is used. The cost of machinery for construction of masonry and concrete is about Rs. 75 lakhs. Only about forty to forty-five per cent of Rs. 75 lakhs is being written off to the rates. The rest will remain as additional expenditure under special tools and plant which will eventually raise the cost of the Project.

9.2.7. No separate suspense accounts are being maintained for all the items under ancillaries and incidentals for which a lump sum provision of Rs. 13.50 per 100 square feet of masonry is made in the rate analysis. In actual cost accounting against a rate of Rs. 13.5 under this head, only a rate of Rs. 9.25 is being assumed. It has been suggested to the Project Authorities that suspense accounts should be kept for all the items under ancillaries and incidentals so that a correct picture of the actual cost under this head would be available.

9.2.8. There is a project provision of Rs. 73 lakhs for composite dam and earthen dam. The composite dam has now been abandoned and on both sides earthen flanks have been provided. It is estimated that cost of both the earthen flanks will be about Rs. 56 lakhs. The total earth work to be done is 32,000 units and with the estimated rate of Rs. 105 per unit it will cost about Rs. 33.60 lakhs. It is, however, seen that the cost of the earth moving machinery, already purchased is about Rs. 112 lakhs. Even allowing for some use of this machinery on foundations and coffer dam, it will appear that the earth work machinery purchased is rather excessive. This is apparent from the fact that the machinery has been used on an average for a very short time daily as explained in Chapter VI—"Construction Features". Either the earth work rate will be exceeded or there will be considerable unwritten off expenditure remaining under special tools and plants in the end.

9.2.9. There is a provision of Rs. 32 lakhs in the 1956 phase estimate for the construction of a bridge on river Krishna, below dam. The estimated cost is Rs. 36.36 lakhs. There was no provision for any such bridge in the 1954 Project estimate, as it was expected that the dam when completed would provide the necessary communication between the two sides of the river. Th bridge has been made unduly wide to provide two narrow gauge lines which are not likely to be used. Mention of this has been made in Chapter VI on "Construction Features."

9.2.10. The 1954 Project provided Rs. 15 lakhs for approach road and camp roads. The 1956 phase estimate provides Rs. 48 lakhs, 18 lakhs for camp roads and services and Rs. 30 lakhs for two approach roads—one on the right bank and the other on the left bank. More approach roads are being constructed at the cost of the Project, which

will cause excess. The approximate cost of camp roads and service roads is as under :—

	Rs. lakhs
1. Macherla to Dam site	14
2. Link to Hyderabad Road	15
3. Colony Roads	18
4. Nalgonda to Halia-Estimated cost Rs. 15 lakhs of which half will be borne by the Roads Deptt. of the State	7·5
Total :	54·5

There will thus be an excess of Rs. 6.5 lakhs under this Head. The question of sharing the cost of the first two items by the State's Road Department is under consideration.

9.2.11. The saving of Rs. 40 lakhs on 'replacement of 1 : 3 cement mortar masonry' is not likely to be realised in full as reported by the Project Authorities.

There is a net provision of Rs. 100 lakhs under special tools and plant in 1956 phase estimate out of which a saving of Rs. 40 lakhs is expected on account of procurement of surplus machinery from other projects. The net debit expected against the Project will thus be only Rs. 60 lakhs. The Team has already explained in Chapter VI "Construction Features" that the saving of Rs. 40 lakhs is not likely to occur.

9.2.12. The unit rates worked out and the actual working rates as are being shown in monthly reports to the Control Board do not seem to be realistic as they do not provide for depreciation of all the machinery that has been purchased. It is the usual practice that when any machinery is purchased, the works to which the cost will be eventually charged, are shown. The Team has suggested to the Project Authorities to prepare a comprehensive note showing to what works the depreciation charges of all machinery purchased, will be debited. No suspense accounts of services like water supply, lighting, electricity are maintained. A lump sum provision of Rs. 9.50 is shown in the actual working rate of masonry per unit for such services. It is, therefore, necessary to maintain proper depreciation and working expenses accounts to arrive at the actual rate of masonry to know whether the estimated rate is being exceeded or not.

9.2.13. In view of all these factors which are likely to affect the estimated cost it is re-iterated that a revised project estimate for the Dam incorporating all changes made in the designs and actual working rates should be prepared at the earliest possible date.

9.3.1. The question of likely excesses and savings on canals has been gone into with the Project Authorities. It is seen that the figures of savings and excesses have been changed from time to time. Unless proper revised estimates on the basis of the present designs are prepared, the position regarding the revised cost of the Project will not be clear.

9.3.2. *Excesses and Savings on Right Bank Canal.*—It has already been mentioned in Chapter V—"Design Features", that the section of the Right Bank Canal has been considerably modified which will affect the estimated cost based in 1954 Project section. Estimates have been prepared for the excavation of the Right Bank Canal from chainage 1,320 to mile 45 (Appendix XIV). The estimated cost is shown as Rs. 800.45 lakhs. The work from chainage 10,555 to 17,045 has not yet been taken up. The estimated cost for this portion is shown as Rs. 1,13,92,000 but the revised estimate for this length is Rs. 215.77 lakhs. The excess on this reach will be Rs. 215.77—11.92 = Rs. 101.85 lakhs. Thus the total estimated cost for this length will be Rs. 800.45 plus 101.85 = Rs. 902.30 lakhs. The Project Authorities were requested to give the project estimate cost for this reach but they were unable to give the same stating that the breakdown of the quantities and cost of earth work mile-wise were not available for the Right Bank Canal. They were not in a position to say whether there have been excesses in this reach or not in comparison to the Project estimate.

9.3.3. The total provision in the estimate under L—Earth work for a length of 135 miles is Rs. 1,263 lakhs. The provision for lining and rubble masonry for which no estimates have been prepared is about Rs. 80 lakhs. The balance left for the remaining 90 miles length of the canal under L—Earth work is thus Rs. 1,263—902—80 = Rs. 281 lakhs only. The length of the main canal is proposed to be reduced from 135 to 116 miles. It is now proposed to take the last distributary at 116 mile instead of 135th mile without affecting the first phase ayacut, but in the second phase, the main canal will have to be excavated from mile 116 to 135 and this will add to the cost of second phase estimate. On this basis the length of the canal remaining to be done will be (116—45) = 71 miles. It is very likely that the balance of Rs. 281 lakhs will not be adequate for the remaining length and there will be considerable excess.

The Project Authorities have stated that the total earth work quantity of the Right Bank Canal will be exceeded by about ten per cent. Excesses are expected both in the cost and quantities of rock excavation. It is, therefore, very necessary that a revised Project estimate should be prepared as early as possible.

9.3.4. It is further seen that there are excesses over the Project estimate on masonry structures, estimates for which have so far been sanctioned. These works are as under :—

Location	Name of structure	As per phase estimate	Sanctiooned	Percentage Excess
6-5-220	.. Road Bridge	65,100	1,95,000	200
14-3-335	.. Road Bridge	79,300	1,62,000	100
11-1-190	.. Chandravanka Aqueduct	12,31,000	29,04,000	135
	Total :	13,75,400	32,61,000	
	Total excess Rs. 18·856 lakhs			

It will be seen that there are very considerable excesses on all the works so far sanctioned. It is, therefore, necessary to know as to how the changes in the design in the section of the canal will affect all the masonry works.

9.3.5. *Excesses and Savings on Left Bank Canal.*—Estimates for excavation of Left Bank Canal have been prepared for a length of thirty-five miles (Appendix XV). The estimated costs have, however, not been compared with the Project costs. It has been mentioned by the Project Authorities that there will be saving on earth work quantities of the Left Bank Canal. This can be verified only when the revised project estimates are prepared.

9.3.6. There is considerable excess on masonry work of one aqueduct, namely Hallia aqueduct, for which estimate has been prepared. The project estimate amount is Rs. 30.49 lakhs and as per sanctioned estimate it is Rs. 44 lakhs. There is thus an excess of Rs. 13.51 lakhs.

9.3.7. In the revised estimate amounting to Rs. 91.12 crores, the provision for cross drainage works on the two Canals has been increased by Rs. 72 lakhs. Even this increased provision is likely to prove inadequate, as there is already an excess of over Rs. 32 lakhs on the four masonry works for which estimates have been sanctioned so far. In the 1956 Project estimate there is a provision for lining for a length of 40 miles for full bed width and a depth of five feet only. It is now proposed to line the whole section for the discharge required in the first phase for a length of forty miles. This is proposed to be done practically within the estimated amount. This has become possible due to the reduced bed width of the canal. The lining for five feet depth only would have been in any case unsatisfactory, as the lining would have been over-topped for a considerable period of the working season and the lining could not have stood. This change was apparently made with a view to reducing the cost in the beginning but without realising the implications of its suitability.

9.3.8. The question of machinery required for the Right Bank Canal and Left Bank Canal has been gone into with the Project Authorities. On the basis of the purchases already made and those further proposed to be made, it was apprehended that if full purchases were made, the machinery may not be utilised to the fullest extent. It had been proposed to purchase machinery worth Rs. 294 lakhs for Right Bank Canal and Rs. 258 lakhs for Left Bank Canal. However, on account of the difficulty of foreign exchange, restricted funds have been given to the Project Authorities for purchase of new machinery for canals. It is seen that machinery worth about Rs. 185.37 lakhs has been purchased for the Right Bank Canal and Rs. 109.92 lakhs for Left Bank Canal. Foreign exchange from Export and Import Bank of U.S.A. to the extent of Rs. 30.92 lakhs has been agreed to be released to the contractor for tunnel machinery. The Team suggests that the greatest caution should be exercised in purchasing further machinery for the canals, specially the earth-moving machinery.

9.3.9. For the Delta area there is a provision of Rs. 100 per acre for distribution system in the revised estimate. The provision for this item on the Right Bank Canal is Rs. 82 per acre of ayacut and that in case of the Left Bank Canal is Rs. 58 per acre which is inclusive of the extra provision of Rs. 31 lakhs provided in the revised estimate for the distributaries and the field channels. The intensity of irrigation on the Left Bank Canal is, no doubt, higher than that on the Right Bank Canal but the gap between the rates on the two canals is considerable. The rate for the Left Bank Canal may be exceeded.

9.3.10. In the latest review of savings and excesses on the two canals, the savings under special tools and plant are shown as Rs. 30 lakhs. The net provision, at present under special tools and plant in the 1956 Project estimate for the two canals is Rs. 92 lakhs only. This is proposed to be reduced to Rs. 62 lakhs because some second-hand machinery has been purchased. It is doubtful if the saving will be realised, particularly as full use is not being made of the earth-moving machinery. This has been explained in Chapter VI.

9.3.11. In view of all these factors, it is all the more essential to prepare the revised project estimates for both the canals incorporating all the changes that have been made in the designs and on the basis of rates obtained in actual working, at the earliest possible date.

9.4.1. *Financial Forecast.*—The Nagarjunasagar Project was started in the last year of the First Five Year Plan, *i.e.* in 1955-56. Before the Project was started, a rough financial forecast picture was given by the two Chief Engineers of Andhra and Hyderabad States as already mentioned. The Project was expected to cost Rs. 75.08 crores and to irrigate 23.6 lakh acres and to give a return of 5.05 per cent on the net capital.

9.4.2. A phased estimate was prepared in October 1956 and this showed that the Project would cost Rs. 86.56 crores exclusive of the cost of construction of Kavali and Kanupur Canals and would give irrigation to 20.6 lakh acres and would yield a net return of 2.64 per cent at the end of the tenth year after completion, *i.e.* at the end of the seventeenth year from the commencement. This return is shown as decreasing thereafter. The financial forecast is prepared on the basis of simple interest of 4.5 per cent on the capital. In the preparation of the financial forecast, the following assumptions have been made :—

(*i*) The irrigation will commence in the Krishna Delta area in the fourth year after starting construction and will go on developing gradually. The Project has already been under construction for more than four years and it is still more or less in the foundation stage. The irrigation in the Delta area cannot, therefore, be started until about the last year of construction.

(*ii*) The development of irrigation of Nagarjunasagar canals will take place within four years after the completion of

the Project or twelve years from the start. The percentage of irrigation development adopted is as under :—

	per cent
First year of irrigation	40·21
Second year of irrigation	65·61
Third year of irrigation	82·01
Fourth year of irrigation	100·00

(*iii*) The recovery of betterment levy is shown from the first year of irrigation development on similar basis without any time-lag for recovery of betterment levy after irrigation water is supplied.

(*iv*) The water cess rates adopted are as under :—

(*a*) First crop wet .. .. Rs. 15·00 per acre for both the canals and Krishna Delta.

(*b*) First crop dry .. .. Rs. 10·00 per acre for Right Bank Canal.
Rs. 7·50 per acre for Left Bank Canal.

(*c*) Second crop irrigation Rs. 7·50 per acre for Left Bank Canal.
Rs. 6·25 per acre for Delta.

(*v*) The working expenses are assumed at Rs. 2 per acre and collection charges five per cent on direct revenue. No separate allowance has been made for maintenance of the Dam.

(*vi*) The revenue from the sale of Peramboke or Govt. land has also been taken during the four years of development of irrigation on the above percentage basis at the rate of Rs. 200 per acre. The betterment levy has also been taken on the Peramboke lands in addition to the sale value of Rs. 200 per acre. All Govt. lands aggregating to 1.82 lakh acres are provided to be sold within four years, during which irrigation development is provided.

Most of the assumptions made seem to be too optimistic and are not likely to be realised.

9.4.3. The Project estimate, as stated already, has been revised and is now expected to cost Rs. 91.12 crores. A fresh financial forecast of the revised estimate has been prepared by the Project Authorities on the basis of a ceiling of Rs. 32.3 crores as expenditure in the Second Five Year Plan and the rest, all in the Third Five Year Plan. This financial forecast was put up to the Control Board in XXII Meeting held on 4th July, 1959 and it is understood that this has been submitted to the Government of India.

9.4.4. On the basis of simple interest of 4.5 per cent on the capital, the return in the revised financial forecast works out to 2.3 per cent at the end of twentieth year after commencement and this keeps on reducing.

9.4.5. The assumptions made in the preparation of this forecast differ from the earlier assumptions as under :—

(*i*) The irrigation in Delta area is shown to commence in the fifth year *i.e.* 1961-62 which is actually the seventh year of construction. It appears that in the financial forecast two years 1955-56 and 1956-57 are taken as preliminary years and 1957-58 is shown as the first year of construction.

(*ii*) The development of irrigation on Nagarjunasagar Canals is provided as under :—

	per cent
First year of irrigation (1965-66)	25·1
Second year of irrigation	50·2
Third year of irrigation	74·3
Fourth year of irrigation	100·0

(*iii*) The recovery of betterment levy is shown from the twelfth year i.e. three years after irrigation water is supplied. The percentage recovery of betterment levy after twelfth year is on the same basis as the percentage for development of irrigation.

(*iv*) The water cess rates adopted are the same as in the original financial forecast excepting that the water cess for second crop irrigation in Delta has been raised from Rs. 6.25 to Rs. 7.50.

9.4.6. The financial return expected may not be fully realised due to the following factors :—

(*i*) As the total area of irrigation to be developed is 20.60 lakh acres which is very considerable, it is likely that more than four years will be required for full development. In the first two years the development may be slow as the channels etc. will have to settle down. However, all steps to construct channels and test them in time and to popularise irrigation practices should be taken.

(*ii*) The working expenses of Rs. 2 per acre appear to be on the low side. The total maintenance charges are R. 35.80 lakhs which give a percentage of 0.39 per cent on the capital cost of Rs. 91.12 crores. Actually in the Krishna Delta the working expenses amount to about Rs. 3.50 per acre (Appendix XII). The topography of the irrigated area in the Delta is much more favourable than that of Nagarjunasagar Canals. There will be many large masonry works to be maintained on the Nagarjunasagar Canals. Besides no separate provision has been made for the maintenance of the Dam itself which is a

very big engineering structure. It is usual to provide separate maintenance charges for dam in addition to the acreage maintenance charges.

9.4.7. The Team makes the following suggestions for improving the financial returns to a certain extent :—

(*i*) Water-cess for the second crop paddy should be increased from Rs. 7.50 per acre to Rs. 12 per acre as water for this crop is to be provided from expensive storage. This has been suggested in Chapter IV, 'Integration of Srisailam and Nagarjunasagar Projects.'

(*ii*) The first crop wet requires twice as much quantity of water as first crop dry, but the water-cess for wet crop is Rs. 15 per acre and that for dry crop Rs. 10 per acre. It would, therefore, be advisable to reduce the percentage of wet crop and increase the percentage of dry crop as far as possible.

(*iii*) The water cess for first crop dry for the Right Bank Canal is Rs. 10 per acre and that for the Left Bank Canal is Rs. 7.50 per acre. The rate for dry crop for the Left Bank Canal may also be raised to Rs. 10 per acre as very costly irrigation systems are being provided for supply of assured irrigation water.

(*iv*) As explained in Chapter VIII on "Power Development" the power potential in the first phase of Nagarjunasagar Project if developed will give a net additional revenue of Rs. 70 lakhs. This will improve the financial return from the Nagarjunasagar Project as a whole.

(*v*) As the second crop requires water entirely from expensive storage and as very much more revenue can be realised from non-paddy rabi crops than that from second crop paddy for the same quantity of water, it would be desirable to develop non-paddy rabi crops as far as possible.

(*vi*) The Delta irrigation will considerably benefit from the stored waters of Nagarjunasagar Reservoir. The working tables provide considerable amount of water to be supplied from the Nagarjunasagar Reservoir, both in the beginning and at end of the Monsoon season, which the Delta does not get from the normal flows of the river Krishna at present. The present irrigation rates are low. The rate for first crop paddy is only Rs. 6.25 per acre. The Team suggests that the water-cess rates in the Delta should be suitably revised for the benefits received from Nagarjunasagar Project and the additional revenue so accrued should be credited to that Project.

9.5.1. In the original financial forecast a phased expenditure of Rs. 60.12 crores was envisaged up to the end of the Second Five Year Plan. Due to reduced allotments, the expenditure by the end of

the Second Five Year Plan is expected to be Rs. 39.07 crores only. A statement giving the phased, budgetted and actual expenditure by the end of the Second Five Year Plan is given below :—

Phase project(All figures in Rs. crores)

Year	Phased	Budgetted	Actual	
1955-56	1·11	1·11	1·09	
1956-57	4·93	4·63	3·63	
1957-58	13·69	13·68	7·35	
1958-59	14·50	8·50	8·50	
1959-60	13·80	8·50	8·50	Expected allotment.
1960-61	12·09	10·00	10·00	Expected allotment.
Total	60·12	46·42	39·07	

9.5.2. There is thus a gap of Rs. 21 crores between the phased and the anticipated expenditure. This is not only likely to delay the completion of the Project by two years but also to add to the interest and over-head charges. The original ceiling on the expenditure in the Second Five Year Plan was Rs. 32.3 crores. The Team is glad to note that the ceiling has been raised by about Rs. 5.7 crores—partly by the State from its own annual allocation and partly by additional loan by Government of India. The Team is of the view that the Project Authorities are in a position to spend much more than what is being allotted annually. The Team suggests that the available funds in the Third Five Year Plan should in the first instance be concentrated on this Project in preference to any other project in the State so that this Project will start giving irrigation benefits at an early date.

CHAPTER X

IRRIGATION DEVELOPMENT AND AGRICULTURAL ASPECTS

10.1.1. The average rainfall in the area commanded is about 30 inches to 35 inches. The Right Bank Canal has been designed on the basis of a duty of 70 acres per cusec for wet crop and 140 acres per cusec for dry crop and the Left Bank Canal on the basis of a duty of 55 acres per cusec for paddy and 150 acres per cusec for dry crop.

10.1.2. The duties are different for the two canals as the projects for the canals were prepared by the two States of Andhra and Hyderabad. It should be possible to obtain a duty of 70 acres per cusec for paddy on the Left Bank Canal too and more so as the intensity of wet crop on the Left Bank Canal is much higher than that on the Right Bank Canal. On the Right Bank Canal the ratio of wet crop to dry crop is 1/3rd : 2/3rd while on the Left Bank Canal the ratio of wet crop to dry crop is about 3/4th : 1/4th. Similarly there are differences in the water cess rates on the Right Bank and Left Bank Canals. The water cess for rice in case of Right Bank Canal is Rs. 15 per acre and that for dry crop is Rs. 10 per acre, while the water cess in case of rice on the Left Bank Canal is the same but for the dry crop the rate is Rs. 7.50 nP per acre. The delta provided for rice irrigation on the Right Bank Canal inclusive of losses in the channels is about 4.1 feet. and that for dry crop 2.05 feet; it is somewhat higher in case of Left Bank Canal.

10.1.3. The scope of irrigation provided in the final phase of Nagarjunasagar Project is shown below :—

Name of Canal	Gross Commanded Area (lakh acres).	Culturable commanded Area. (lakh acres).	Irrigation (lakh acres)					Remarks.
			First Crop		2nd crop Wet	Perennial	Total	
			Wet	Dry				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Right Bank Canal	38·47	33·36	5·60	11·10	—	—	16·70	As per figures supplied by Project Authorities.
(*i*) Kanupur Canal.	—	1·57	1·10	—	—	—	1·10	As per 1954 Project.
(*ii*) Kavali Canal.	—	1·14	0·78	—	—	—	0·78	

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Left Bank Canal								
(*i*) Old Hyderabad	14·41	9·87	4·50	1·85	1·20	0·40	7·95	As per 1954 Project.
(*ii*) Andhra	—	2·93	1·85	0·20	—	—	2·05	
Delta ..	—	—	1·50	—	1·50	0·25	3·25	
TOTAL ..	52·88	48·87	15·33	13·15	2·70	0·65	31·83	
Left Bank Canal Extension ..	12·52	8·76	1·2	2·3	—	—	—	As per figures supplied by Project Authorities.

10.1.4. It will be seen that most of the irrigated area is of the first crop, which has resulted in the capacity of the canals being kept considerably high in comparison to perennial canal systems. This seems to have been done with a view to providing irrigation benefits to as large an area as possible. This is in accordance with the recommendation contained in the Khosla Committee's Report (1953) on "Optimum Utilisation of the Krishna and the Godavari Waters". The recommendation was that the scheme should provide irrigation to first crop over as large an area as possible.

10.2.1. When the 1954 Project Report was prepared, Hyderabad and Andhra were two separate States. The irrigation demands, duties and water cess rates were provided on different basis. Now that the whole area lies in Andhra State, it would be desirable to have uniformity as far as possible. The Team suggests that the water-cess for the dry crop in case of the Left Bank Canal, which is Rs. 7.50 per acre may be raised to Rs. 10 as in the case of Right Bank Canal. The crops will be equally valuable on both sides.

10.2.2. It may be mentioned that the dry crop, which requires half or less than half of the quantity of water required for wet crop of paddy, yields a revenue of Rs. 10 per acre, while the paddy gives a revenue of Rs. 15 per acre. Thus from the point of view of financial returns from the same volume of water, dry crop irrigation is more economical than rice irrigation. It would, therefore, be desirable to restrict paddy irrigation as far as possible on both the canals and extend the scope of dry crop irrigation. Extension of dry crop irrigation will further improve the intensity and the duty.

10.2.3. The intensity of irrigation on Right Bank Canal is about 50 per cent with respect to the culturable commanded area and that on Left Bank Canal is about 78 per cent. It should, therefore, be possible to get a better duty for wet crop on the Left Bank Canal than that provided in the Project.

10.3.1. The Left Bank Canal works as a perennial canal for forty miles and provision has been made for green manure crops etc. The Right Bank Canal is entirely a first crop canal and would flow from middle of May to middle of December.

10.3.2. If canal water has to be of maximum benefit, fertility of soil, which is already at the lowest ebb in the area coming under irrigation, must be raised by green manuring practices. However, green manuring is difficult, in case, canal is to run only from mid May to mid December as there is hardly any time left to sow and nourish any green manure crop, much less to bury the same in time so that it becomes available for the succeeding crop. It is only the provision of irrigation water in early part of the year—no matter if in small quantity—which is a necessary pre-requisite to successful green manuring practice.

10.3.3. During its tour from Nagarjunasagar to Guntur, a distance of about 100 miles, the Team accompained by the Director of Agriculture as also some members of Irrigation Department, saw cotton and other summer crop grown over a large area of land, even under barani (rain-fed) conditions. Cotton plants were only a foot high, bearing one or two bolls with an expected yield of 1 to 1½ mds. per acre. With the advent of canal irrigation people are bound to grow crops like cotton on a bigger scale but they will be severely handicapped if canal water is made available after June and cotton sowing is delayed upto June—July, as is the prevailing practice in the rain-fed area these days. According to results of numerous experiments conducted in the Punjab and elsewhere, cotton sown a month or two before rainy season sets in say in April—May, (all other things being equal) gives much higher yield, even more than 100 per cent, than if sown in June-July. Cotton sown in April—May would not require more than one or two irrigations until June but, if results obtained in other places hold good in Andhra as is expected, it would make tremendous difference in the crop yields. Accordingly, water made available in the early part of the year, even though in small quantity, will not only enable the cultivators to grow some crops which they cannot grow otherwise during the season but it will also help them to obtain greater yields of crops like cotton because of early sowing.

10.3.4. As mentioned in Chapter on "Integration of Srisailam and Nagarjunasagar Projects" in 75 per cent of the years there will be some extra water available over and above the requirements of assured irrigation, some of which can preferably be used for green manure crops and early cotton sowing. Even in the remaining 25 per cent of the years it should be possible to provide some water for early cotton with some slight adjustment in the pattern of wet and dry crops on the two Canals.

10.4.1. *Area to be left out of irrigation*—The following figures show the area to be irrigated on Right Bank Canal as compared with the gross area, total culturable commanded area and area left out as Anti-Malarial Zones etc :—

	lakh acres
1. Gross area	38·47
2. Total Culturable Commanded Area	33·36
3. Total area of anti-malarial zones	2·13
4. Total irrigable area	21·34
5. Area to be actually irrigated	16·70

Thus the total area to be actually irrigated is 43.4 per cent of the gross area, 50 per cent of culturable commanded area and 78 per cent of the irrigable area.

10.4.2. According to the present plans, some area has to be altogether left out of irrigation and this area, as is apparent from the perusal of all irrigation maps of distributaries, is proposed to be located on both sides of the main distributaries on the ridges as illustrated in the map, opposite, showing ayacut plan on Matsavaram Major Distributary. Reasons underlying this decision, as explained to Members of the Team personally, seemed to be that water, if applied to the area in the upper ridges, will in any case be drained down to the low lying area in the valleys and ultimately bring about water-logging and also salinity on account of salts that will be carried with water from soils in the upper area. On the other hand, if, as planned at present, the canal water is carried down to the lower areas and utilized there for wet or semi-wet cultivation, then water-logging and salinity problems will be avoided. Surplus water will escape in the drainage channels, rivulets or streams down below the valley.

10.4.3. However in the opinion of the Team the above fears do not seem to be justified in view of the following factors :—

(*i*) the area near the ridges being relatively flat is easily amenable to flow irrigation without much need for levelling etc;

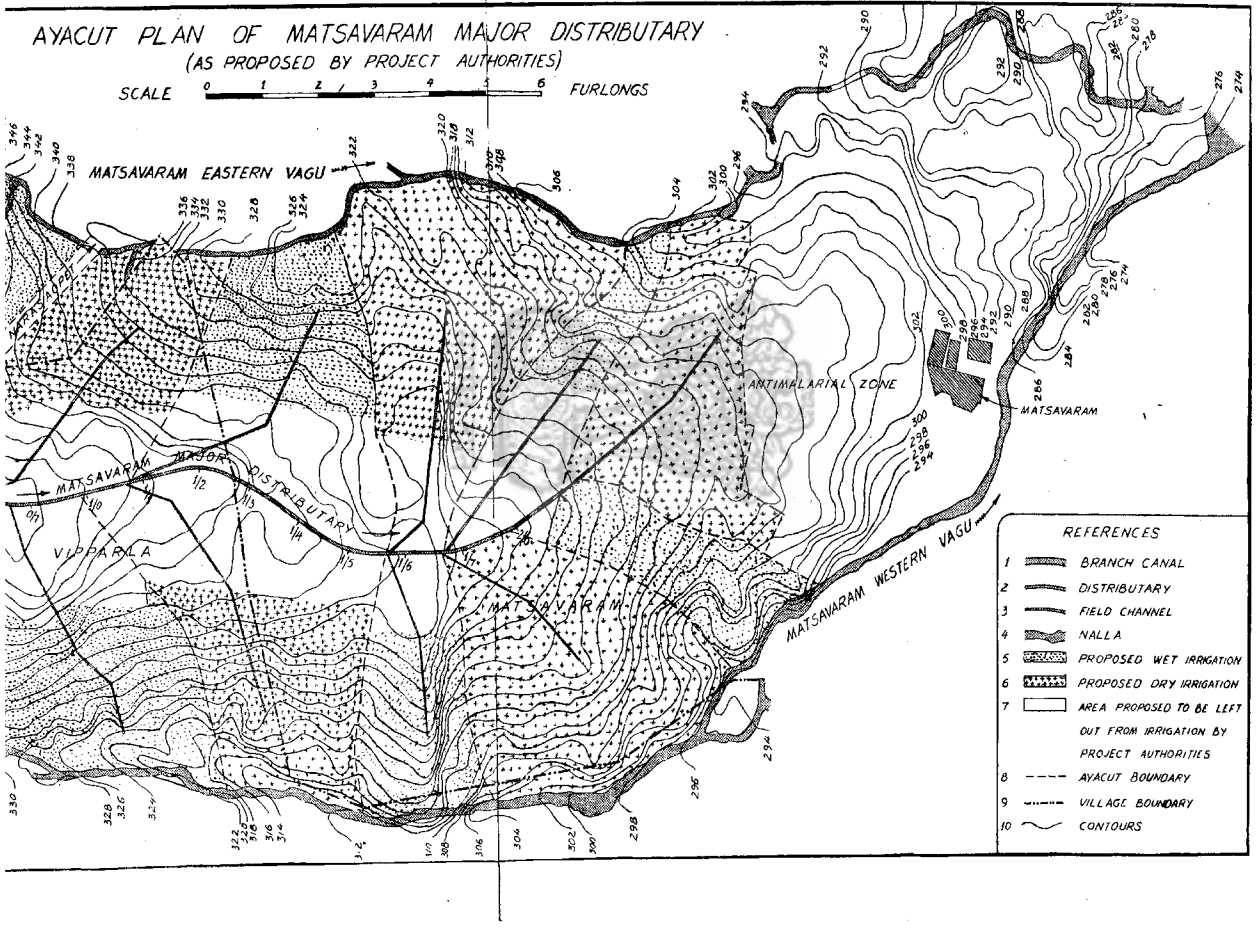
(*ii*) these areas are at present being utilised for crops like cotton which after the advent of irrigation could be further intensified;

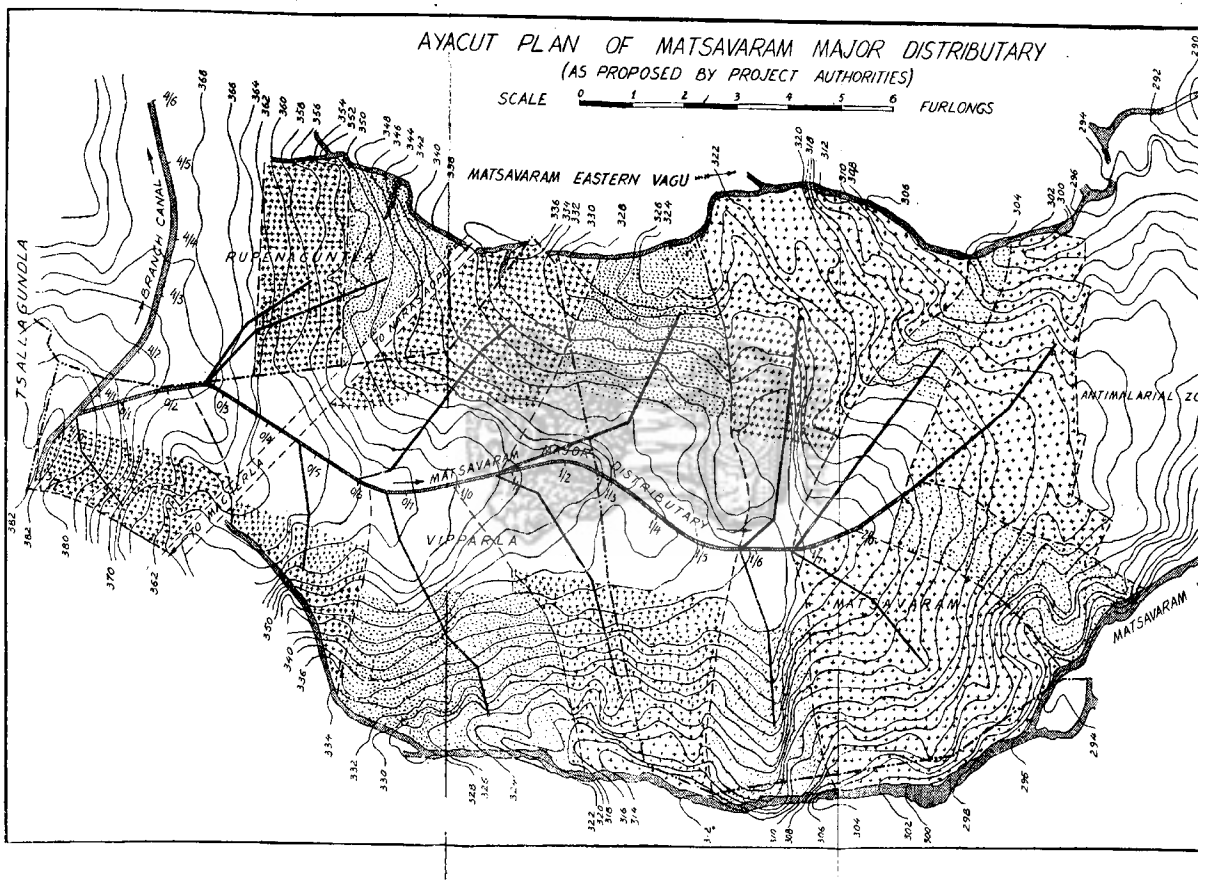
(*iii*) normally the problem of salinity is not so serious on the ridge lands as they are washed by rain which is of the order of 30 inches to 40 inches per annum. On the contrary, salts if any tend to accumulate in the lower lands;

(*iv*) if the lands lying on both sides of the distributaries are brought under cultivation of fruit trees, vegetables or cotton plantation which have deep root systems, then the seepage of water from the distributaries would be readily utilised by these plants and accumulation of salts on the surface would be avoided;

(*v*) in fact once the fruit trees get fully established only a little additional irrigation is required for subsequent years, since, their deep roots utilise the seepage water from the sub-soil and thereby Government will earn a handsome revenue;

(*vi*) unlike the lands lower down, the lands on the ridges around distributaries are not capable of being irrigated with sub-soil water which is very deep and hence these lands should be the last ones to be ever left out;


AYACUT PLAN OF MATSAVARAM MAJOR DISTRIBUTARY
(AS PROPOSED BY PROJECT AUTHORITIES)
SCALE 0 1 2 3 4 5 6 FURLONGS
MATSAVARAM EASTERN VAGU
MATSAVARAM MAJOR DISTRIBUTARY
VIPPARLA
MATSAVARAM
ANTIMALARIAL ZONE
MATSAVARAM WESTERN VAGU
REFERENCES
1 BRANCH CANAL
2 DISTRIBUTARY
3 FIELD CHANNEL
4 NALLA
5 PROPOSED WET IRRIGATION
6 PROPOSED DRY IRRIGATION
7 AREA PROPOSED TO BE LEFT OUT FROM IRRIGATION BY PROJECT AUTHORITIES
8 AYACUT BOUNDARY
9 VILLAGE BOUNDARY
10 CONTOURS


AYACUT PLAN OF MATSAVARAM MAJOR DISTRIBUTARY
(AS PROPOSED BY PROJECT AUTHORITIES)
SCALE 0 1 2 3 4 5 6 FURLONGS
MATSAVARAM EASTERN VAGU
TSALLAGUNDLA
BRANCH CANAL
RUPANAGUNTLA
MATSAVARAM MAJOR DISTRIBUTARY
VIPPARLA
MATSAVARAM
MATSAVARAM
ANTIMALARIAL ZO

(*vii*) application of canal water to lower lands would result in irrecoverable loss of water due to seepage into nallas and natural drainages, whereas application of water to upper lands would result in the seepage water being stored in the sub-oil of the lower lands, from where it could be recovered for irrigating additional crops, by means of lift irrigation;

(*viii*) in case, any land fit for cultivation and amenable to canal irrigation is at all to be left, it should be only the lands at the bottom of the valleys and situated far away from the distributaries where alternative arrangements to irrigate the same by lift irrigation is not only feasible but desirable; and

(*ix*) Giving irrigation water to these lands adjoining the distributaries would avoid the unpleasant task of acquiring lands for the distributaries from persons who would have to forego the benefit of irrigation in the system of irrigation contemplated by the Project Authorities.

Therefore, the Team suggests that the above factors should be given full consideration before the lands adjoining the distributaries are deprived of irrigaton benefits.

10.4.4. *Lift Irrigation and use of sub-soil water in Valleys* :—Conceding that every possible effort must be made to extend the benefits of canal irrigation to the widest possible area, the chances of lift irrigation should be fully explored. Obviously areas, where the water table is high, offer the maximum chances of success. Such conditions are met with in the case of lands which are situated at the bottom of the valleys. In some cases, the water table, even at present, is found to be only 2—5 feet from the ground level and it comes upto ground level in rainy season. With the advent of canal irrigation, the water table is bound to rise still further. Our efforts should be not to add more water to this area, which will be the net result if canal irrigation is largely done in such areas as contemplated at present, but to remove some of the sub-soil water by lift irrigation. This will help not only to irrigate lands lying a few feet above but also to keep the lands in the lower area under cultivation, by safeguarding against water-logging and salinity. If arrangements can be made for the provision of electricity for running the pumping sets in the valleys, lift irrigation is bound to become a popular and paying proposition.

10.4.5. Accordingly, supplying canal water to the upper areas of land and encouraging lift irrigation, *e.g.* open cheap wells fitted with pumping sets, in the lower reaches should be the dominating policy in an integrated plan of the Project Authorities. People could be given loan or even subsidies for sinking wells and installing pumping sets. Water rates or land revenue could also be reduced in the initial stage as an incentive to cultivators to resort to lift irrigation. Possession of

to incur even heavy expenses of irrigation per acre per year. Adoption of this policy will also obviate the need of depriving any large area from receiving the benefits of irrigation and ensure good chances of providing irrigation to the whole area with little danger of water-logging and salinity and without any wastage of water.

10.4.6. *Anti-malarial zones also to receive irrigation.*—According to the original plans certain areas of land—(two miles around each town and half a mile around each village to be declared as Anti-Malarial zone) are proposed to be deprived of the benefits of irrigation to avoid mosquito breeding. The area thus affected is approximately 12.02 lakh acres. The scheme did not appeal to the Team for various reasons. Lands around villages and towns are not only very expensive but also generally fertile for obvious reasons. Such lands are ideally suitable for growing vegetables, fruit trees and fodder crops that are badly needed by the village or town people. As these lands fetch high income, it would be a pity not to make the best use of the same. Besides, gardens around villages and towns greatly modify the rigours of extreme climate and lessen the ferocity of dust storms— a common feature of this area. Absence of gardens would make villages and towns parched, rugged and desolate. In fact, it is the area around villages and towns which, instead of being left out of irrigation, should actually be given top priority in irrigation. Of course, cultivation of crops like rice which require standing water may not be permitted. Finally, it is actually from the land owners of such areas that betterment levy and irrigation charges could be expected to be readily realised.

10.4.7. It is noteworthy that in a meeting with the Agricultural and other officers held at Miryalaguda on the 8th February, 1959, the Malaria Engineer, Malaria Institute of India, readily agreed with the suggestions to recommend to the Project Authorities not to deprive such areas of irrigation water, but to encourage the cultivation of fruit trees, vegetables and other crops NOT requiring standing water so that it would help to prevent mosquito breeding on the one hand and best utilisation of the area on the other. This will involve certain amount of modification in the estimates of total acreage and localisation of area proposed under irrigation.

10.5.1. *Localisation of Irrigated Area.*—Eight different alternative plans had been under discussion by the Project Authorities. According to the present plan certain areas are to be left out of irrigation for ever whereas other areas receiving irrigation are intended to be permanently earmarked as suitable for (a) wet cultivation or heavy irrigation as for rice and (b) semi-wet or dry cultivation for crops requiring light irrigation. This plan seems unjustified both on grounds of agricultural practice and equitable justice.

Firstly, there would be some justified resentment by the cultivators on this differential treatment in earmarking certain areas to receive "no irrigation" some "light" and some "heavy" irrigation for all times

10.52. *Concentration of crops*—Undoubtedly, concentration or localisation of certain kinds of crops in certain specified areas in any locality or village durng a cropping season is a "laudable objective" from the view points of economy in the use of water, supervision of crops, disease and pest control, farm-management practices and various other reasons. But this objective can be achieved by some other methods as well, such as dividing in two portions the land of each village or part of village, comprising sufficient area say 250—500 acres as unit, and giving heavy irrigation to one half area in one season followed by light irrigation in the same area in the succeeding season. Such an arrangement will help in the rotation of crops, which is a desirable practice, and also in the concentration or localisation of certain crops in different seasons without causing any hardship or giving cause of complaint to anyone for different treatment.

10.6.1. *Change over from dry-cultivation to wet-cultivation and necessary preparation*—Change over from dry cultivation to wet cultivation brings about revolutionary changes not only in agricultural economy and crop pattern, but even in the methods of cultivation or agricultural practices etc. Crops like bajra and jowar will be partially replaced by more remunerative crops like potatoes, vegetables, cotton and other cash crops and also by fodder crops for the live stock. Even in regard to production of normal crops, tremendous changes in the methods of cultivation, time of sowing, seed-rate etc. are generally called for, as a result of change over from dry to wet cultivation. Varieties of cotton or other crops suitable for dry areas are not necessarily suitable under irrigated conditions and nor is their time of sowing or seed rate per acre the same.

10.6.2. Similarly, it is certain that when canal water becomes available, people will go in for fruit plantations for which there is good scope. But mistakes once committed in fruit gardens, such as in the lay-out of garden or in the selection of varieties of fruit trees, cannot be rectified, except at a tremendous cost and wastage of several years. For this purpose it is necessary for the Department not only to carry out experiments to find out the kind and varieties of fruit trees suitable for the locality but also to be ready to supply nursery plants of suitable varieties to the public, so that fruit industry does not get started on the wrong lines.

10.6.3. Necessary experimental work has to be undertaken to find solutions to the numerous problems that will face the cultivators with the advent of canal irrigation. This is required to be done well in advance as it takes several years of experimentation before authentic results become available.

10.6.4. While it is gratifying to note that the Agriculture Department is fully alive to this necessity and the Project Authorities are also very keen in the matter and there also exists a Development Committee comprising Members of both the Departments, yet unfortunately much headway in the matter of starting experimental work has not so far been made even on urgent problems. What is needed, is to have atleast two experimental stations, one on the Right Bank Canal and

the other on the Left Bank Canal, to carry out the following experiments :

(*a*) varietal trial on important crops like paddy, sugarcane, cotton, jowar, groundnuts etc. It can not be too strongly emphasized that difference in yield between two varieties of the same crop may sometimes amount to several times the water rate to be collected. The farmer must know, therefore, the most suitable variety of each crop to be grown under wet farming;

(*b*) manurial experiments to find out the nutritional requirements of different crops under local conditions as results obtained at other places may not at all be applicable here;

(*c*) green manuring crops from the point of view of their suitability and demonstration to the farmers to improve and maintain the fertility of soil;

(*d*) cultural practices, which naturally vary greatly under wet farming;

(*e*) water requirements of different crops for most economic utilisation of water; and

(*f*) fruit garden for varietal trials to determine the varieties best suited; and trees of successful varieties will later on be utilised as mother trees for nursery plants for supply to farmers.

Apart from this, there would also be need for arranging demonstrations on private farms. These demonstrations may be started at the rate of at least one demonstration in a radius of five miles or say one for every twenty-five square miles, the total number of demonstrations needed will be of the order of 100. All these must be arranged well in advance.

10.7.1. *Road Development and Market Centres*—The remarkable success of colonization in the newly canal irrigated areas of West Punjab (now Pakistan), leading to the proverbial prosperity of the farming community there, was largely due to the fact that simultaneously with the completion of canal system they had also constructed a net work of metalled roads throughout the irrigated area and also market centres which enabled the farmers not only to transport their commodities cheaply but also to fetch good price for their produce. Big Mandis (Markets) carrying out business worth crores of rupees sprang up in no time where none existed before.

10.7.2. At present, the roads in the ayacut and round about are rather in a dilapidated condition and difficult to negotiate. In rainy season, some roads become impassable. The depreciation and wear and tear of numerous Government vehicles even now plying on these roads is heavy. It should be remembered that in the absence of good roads, the transport cost of farm produce would be almost prohibitive and the farmers will not be able to get for their produce the price that they would otherwise expect and the financial loss, that they may

have to suffer on this account in one or two cropping seasons alone, may amount to almost the total cost of road construction. Good roads and adequate market facilities should, therefore, receive adequate attention in the integrated plan of the Project.

10.8. *Survey of Sub-soil Water Level*—Both in connection with the studies of irrigation tanks in Andhra and visit to various areas coming under Nagarjunasagar Dam, the Team had observed the incidence of water-logging, especially in some low lying areas and land becoming highly saline and unfit for cultivation. Water-logging is working havoc in many parts of India, devastating millions of acres of once fertile land. It is, therefore, desirable to carry out detailed survey of sub-soil water level in the whole area to be irrigated by this Project in order to determine the "danger zones" to be guarded against water-logging and to take necessary remedial measures in proper time.

A. N. KSHOSLA.
Leader.

22nd July, 1960.

CHAPTER XI

SUMMARY

I—Scope and estimated cost of the Project

11.1. The Joint Report prepared by Andhra and Hyderabad States in 1954 forms the basis of the present Project. The First Phase of the same, as estimated in October 1956, was to cost Rs. 85.5 crores to irrigate 20.6 lakh acres. This phase envisaged construction of a dam to a partial height upto F.R.L. 525, but to a full thickness required for the ultimate height upto F.R.L. 590. Irrigation was to be done as under :—

	Lakh acres
Delta	
First crop	1·5
Second crop	1·5
Right Bank Canal (140 miles)	
First crop	9·7
Left Bank Canal (108 miles)	
First crop	6·7
Second crop	1·2
	20·6

The estimate has since been revised due to increased cost of cement, steel, etc., and now amounts to Rs. 91.12 crores. The Control Board has given its approval to this estimate, but sanction of the Government of India is yet to be accorded.

II.—Availability of Water.

11.2.1. The question of adjustment of allocations of Krishna waters, on the basis of 1951 Award, due to the reorganisation of the States is under consideration in the Ministry of Irrigation and Power. The Team recommends that this question should be finalised at an early date as already suggested in the Team's Report on Koyna Project.

11.2.2. The 1954 Nagarjunasagar Project is based on the yields of the Krishna river for the year 1929-30, which are 12 per cent in excess of the dependable yield assumed in the 1951 Award of the Planning Commission and give a dependability of 76 per cent against 86 per cent in the Award. On the basis of dependable yield of 1745 T.M.C. Feet assumed in the Award, there is just sufficient water for irrigation at Nagarjunasagar of the area provided in the final phase of 1954 Project. No water is available for (i) irrigation and evaporation losses at Srisailam and (ii) the extension of 3½ lakh acres of

irrigation on Nagarjunasagar Left Bank Canal as now contemplated. The Central Water and Power Commission and the Project Authorities have suggested that in the interest of increasing production of food crops the dependability for assured irrigation projects in the Krishna Basin may be fixed at about 75 per cent. The Team recommends that 75 per cent dependability may be accepted for the purpose of sanctioning projects in the Krishna Basin. On this basis the above extra irrigation uses at Nagarjunasagar and Srisailam can almost be met.

11.2.3. The Project provides for 1.5 lakhs acres of additional first crop irrigation in the Krishna Delta area. The area has already been provided with Krishna water under minor irrigation programme. The Project Authorities have now proposed taking up an equivalent additional area on Nagarjunasagar Canals. It is pointed out that water is not available, even on the basis of 75 per cent dependability, for this additional area. This point should be kept in mind in considering the availability of water for Krishna-Pennar Canal in case this additional area is retained on Nagarjunasagar Canals.

III—Feasibility of First Phase Project.

11.3.1. The Working Tables for the First Phase of 1954 Project are based on an assumption that no new projects out of the allocations of 1,000 T.M.C. Feet of Krishna waters to the various States will be undertaken by the upper States, whereas a number of new projects are already under construction above Nagarjunasagar. The F.R.L. of 525 of Nagarjunasagar Reservoir provided in the First Phase of 1954 Project is hardly adequate for the irrigation of 20 lakh acres of first crop as the lowest reservoir level is shown as R.L. 486, in Table No. III of 1954 Project Report, whereas the sill level of the head sluices of the two Canals is at R.L. 490.

11.3.2. In spite of the above difficulty, the scope of the First Phase has been further increased in the 1956 First Phase estimate. The irrigation provided consists of 17.9 lakh acres of first crop, 2.7 lakh acres of second crop and 7.65 lakh acres of catch crops on the Left Bank Canal. No working tables seem to have been prepared to see, if it would be possible to do the second crop irrigation with F.R.L. 525 proposed for the revised First Phase. The Team has prepared Working Table No. I-A for the First Phase irrigation as provided in 1956 Project for the year 1937-38, which is a year of 75 per cent dependability, on the assumption that the upper States will be utilising half of their allocations for the new projects which roughly tallies with the actual constructions undertaken. On this basis it is seen that only about two-thirds of the first crop irrigation and no second crop provided in the First Phase can be done. In view of these limitations it would be necessary (i) either to curtail the length of the Canals to do about two-thirds of the first crop irrigation or (ii) to complete the masonry of the Dam to the final height, leaving the installation of the gates to be done in the Second Phase and to do as much irrigation as possible with the raised F.R.L. 546 which is recommended to be kept as the sill level of the spillway gates.

11.3.3. The Team has prepared Working Table No. I—B with F.R.L. 546 from which it will be observed that full first crop irrigation provided in 1956 Project and 1.25 lakh acres of the second crop in the Krishna Delta can be done. In addition, about 40 MW of continuous firm power can be generated. The extra masonry involved would be only about 20 M.C. Feet which is one extra season's work. This will cost about Rs. 2.5 crores if done in continuation of the present programme. It will cost much more, if postponed to the final phase. In view of the several advantages, the Team recommends the second alternative. The extra funds of Rs. 2.5 crores will be required in the first year of the Fourth Five Year Plan.

IV—Integration of Srisailam and Nagarjunasagar Projects.

11.4.1. The storage provided in the final phase at Nagarjunasagar upto F.R.L. 590 is just adequate for the irrigation provided in the 1954 Project without support from any upper dams (Team's Working Table No. II). By proper integrated working of Nagarjunasagar Dam with the Srisailam Dam to be constructed 64 miles upstream, the F.R.L. of Nagarjunasagar could have been lowered to F.R.L. 544 for all the assured irrigation benefits provided in 1954 Project and additional 3.5 lakh acres proposed to be provided on Left Bank Extension (Working Table No. IV). This would have resulted in a reduction of Rs. 7.5 crores in the cost of the Dam.

11.4.2. The Srisailam Hydro-electric Project as contemplated by the State Government provides for a storage of 308 T.M.C. Feet upto F.R.L. 885 of which 150 T.M.C. Feet from R.L. 885 to 854 is proposed to be let down in regulated flows for developing firm power of 260 MW at 60 per cent load factor. The minimum draw down level of 854 at Srisailam has been determined by the requirements of the Krishna-Pennar Canal.

11.4.3. The Team is of the view that there is scope for development of more firm hydro-power to the extent of 377 MW at 60 per cent load factor at Srisailam by lowering the draw down level from R.L. 854 to R.L. 830, thus utilising 210 T.M.C. Feet of stored water for generation of power. The draw-down level will go below R.L. 854 for three fortnights only (Working Table No. IV). It is feasible to install suitable reversible hydro-generating sets at Krishna-Pennar Canal intake. These units will be generating power normally; when reversed, they can pump water into the Krishna-Pennar Canal, when the lake levels are lower than the Canal supply levels. The power required for pumping in the three fortnights is small as compared with extra generation of 117 MW of firm power which is possible by lowering the Srisailam lake level to R.L. 830. However, it should be recognised that construction of any of the other proposed power reservoirs upstream of Srisailam will enable maintaining of minimum reservoir level at Srisailam above R.L. 854. As such upper power potentials will doubtless be exploited in due course, whether any installation of pumping scheme for Krishna-Pennar Canal at Srisailam is at all necessary, may be determined with reference to the phasing of the

projects upstream of Nagarjunasagar. The Team's method of operation will also give an extra saving of not less than Rs. 62 lakhs annually in the integrated power system due to the greater generation of hydro-energy.

11.4.4. It has been suggested by the Central Water and Power Commission that surplus storage in Nagarjunasagar Reservoir above the level of 544 required for the full contemplated assured irrigation will be most useful for irrigating additional second crop in surplus years. The Team has worked out the scope for such additional irrigation with F.R.L. 590 (Statement III) and found that an area of 3.31 lakh acres of additional second crop can be done annually on an average. This will give a return of 3.3 per cent on the capital of Rs. 7.5 crores required for raising the F.R.L. from 544 to 590. From general considerations and the revenue return on the capital involved which compares favourably with the return of 2.2 per cent in the First Phase, it would not be desirable to lower the height of the Dam at this stage particularly as the actual saving will now be much less as the masonry of the Dam is being built for the full section required for F.R.L. 590.

11.4.5. First crop irrigation is partly done from storage and partly from the river flows in the Monsoon season, but the second crop irrigation has to be done entirely from costly storage water in the winter season. The Team, therefore, recommends that the water-cess for the second crop paddy may be raised from Rs. 7.50 to Rs. 12 per acre, that for the first crop paddy being Rs. 15 per acre as proposed in the Project Report.

V—Design Features

11.5.1. It is seen that many important design features of the Dam have been changed and these changes will materially affect the estimate of the Project. It is, therefore, essential that a revised project estimate should be prepared at the earliest possible date on the basis of the changes made to get a realistic picture of the likely cost.

11.5.2. The spillway was originally designed for a high flood discharge of 10.27 lakh cusecs with an additional capacity of 20,000 cusecs through the Dam sluices. For this purpose twenty-seven spillway bays of $60' \times 30'$ and twelve river sluices of $6' \times 9'$ were provided. When the construction work was started, the flood capacity was increased to 11.87 lakh cusecs for 100 years frequency and for this purpose twenty-four bays of $50' \times 40'$ and twelve river sluices of $5' \times 9'$ were provided. The high flood discharge for 1,000 years' frequency was worked out by Central Water and Power Commission as 13.85 lakh cusecs, which the Team considered to be low. This discharge was calculated to pass over the spillway with a rise of four feet above F.R.L. of 590 by encroaching on the free board. The safety of the Dam was checked for M.W.L. of 594 and it was found to be structurally safe.

11.5.3. As a result of discussions with the Team, the Central Water and Power Commission have since stated that the high flood discharge

for 1,000 years' frequency at the Dam site will be 15.31 lakh cusecs and that the same will still pass over the designed spillway with a rise of four feet above F.R.L. 590 as a result of routing of the flood through the Reservoir which was not taken into account previously.

11.5.4. Previous model experiments had indicated that the co-efficient of discharge adopted in working out the flood discharges at Vijayawada Anicut, on the basis of which the flood discharges at the Dam site were estimated, was on the low side. Fresh model experiments are proposed to be made by the Project Authorities. If these experiments indicate a higher co-efficient of discharge than hitherto used, the high flood discharge of 15.31 lakh cusecs estimated for a 1,000 years' frequency will need to be further increased.

11.5.5. In the adjoining Godavari Valley, in connection with the Rampadsagar Project, the high flood discharge for 1,000 years' frequency was worked out as 30.6 lakh cusecs based on the data available upto 1951. A high flood of 30 lakh cusecs was recorded on 15th August, 1953. Another high flood of similar magnitude occurred on 17th September, 1959. Thus within a short period, a high flood approaching that of 1,000 years' frequency has already been experienced on this river twice. On the basis of the further data, the 100 years' and 1,000 years' frequency floods would far exceed those assumed in the Project. It would not be unreasonable to expect a similar situation arising in the adjoining Krishna Valley.

11.5.6. It would be most unwise to take any chances with the safety of a large dam, like the Nagarjunasagar Dam, considering the nature and the magnitude of the risks involved. The Team is of the view that the spillway capacity of this Dam should be designed for a flood of the magnitude of a 1,000 years' frequency, at present estimated at 15.31 lakh cusecs, but to be further increased, should the proposed model experiments indicate a higher co-efficient of discharge for the Vijayawada Anicut. This capacity should be without encroachment on the free board.

11.5.7. To cater for a flood discharge of 15.31 lakh cusecs, the present spillway capacity can be increased by providing three extra bays, which is possible under present stage of construction and by providing 44 feet high gates instead of 40 feet gates. The extra cost involved is about Rs. 35 lakhs. Any additional capacity later found necessary can be provided on the left bank, as it is understood that there is a suitable site for a saddle spillway in the Tiger Valley on that bank.

11.5.8. There have been some major changes in the designed sections of the Right Bank and the Left Bank Canals which will affect the Project estimates. The Team has suggested to the Project Authorities that the revised project estimates should be prepared as early as possible.

11.5.9. The Left Bank Canal, which was originally designed for a full supply discharge of 11,000 cusecs is now being constructed on the basis of a full supply discharge of 15,000 cusecs. The increase

in discharge is intended to irrigate an extra area of 3.5 lakh acres beyond the tail reach. The earthwork is being done for a discharge of 11,000 cusecs, but the masonry structures are being constructed for a discharge of 15,000 cusecs. The extra cost of the masonry structures in the First Phase will be Rs. 40 lakhs. Water will be available for the extra area on the basis of 75 per cent dependability. There is no alternative source for irrigating most of this additional area. The remodelling of the masonry structures later on will not only be difficult, but would involve greater cost. The State Authorities should obtain the concurrence of the Government of India to this change which is desirable due to the above considerations and which the Team supports.

11.5.10. Many changes have been made in the design features of the Left Bank Canal in the head reach, presumbly from economic considerations, but without fully considering their effect on the working operations of the Reservoir. The full supply level of the Canal at the head has been raised from about R.L. 508 to R.L. 524.5. Originally twin tunnels with a waterway of 1,100 square feet for a discharge of 11,000 cusecs and giving a velocity of 10 feet per second were provided in the head reach. The flume section in rock cutting was $20' \times 50'$. In the revised design one tunnel with a waterway of 850 square feet has been provided for a discharge of 15,000 cusecs and the flume section has been changed to $40' \times 32'$. The velocity in the tunnel is over 18 feet per second. These changes have resulted in considerable loss of head and in the minimum reservoir level being kept at R.L. 520 against R.L. 510 provided in the original Project. Thus the storage between R.L. 520 and 510 cannot be used to the same advantage as it can be done if the full supply level of the Left Bank Canal was lowered by ten feet.

11.5.11. There are two alternatives for lowering the full supply level of the Left Bank Canal by 10 feet. One alternative would be to increase the size of the tunnel under construction from 32 feet diameter to 38 feet diameter and to lower the bed of the flume upstream of the tunnel. The second alternative would be to provide a second tunnel of appropriate size later when the extension of the Left Bank Canal is undertaken but to construct suitable approaches upstream and downstream of the tunnel now. As it will be several years before the Left Bank Canal Extension is constructed, the second alternative appears advisable. The Project Authorities have accepted this. The resulting advantages of lowering the full supply level of the Left Bank Canal will be :—

(*i*) the full supply level of the Left Bank and Right Bank Canals will be close to each other, resulting in both the Canals making use of the storage under similar conditions;

(*ii*) the velocity in the tunnel will decrease from over eighteen feet per second to under thirteen feet per second. This will increase the life of the concrete lining of the tunnel considerably; and

(*iii*) the minimum operation level will be reduced from R.L. 520 to R.L. 510 originally envisaged in 1954 Project. This will result in more water becoming available in surplus years for additional second crop irrigation which on an average will be about 42,000 acres per annum (Statement III). This will give an extra revenue of Rs. 3.15 lakhs on the basis of Rs. 7.50 per acre assumed in the project report and Rs. 5 lakhs on the basis of Rs. 12 per acre recommended by the Team.

VI—Construction Features.

11.6.1. It is noticed that a railway line has been constructed from Macherla to the Right Bank side of the Dam at an approximate cost of Rs. 50 lakhs for a distance of about 14 miles, for bringing about 6 lakh tons of cement and about one lakh tons of other material. A black topped road has also been constructed from Macherla to the Dam site at a cost of about Rs. 14 lakhs. The haulage charges for cement by railway would be Rs. 2.75 per ton exclusive of the depreciation charges on the capital cost of Rs. 50 lakhs. The cement will have to be transported by road in bulk cement carriers for a distance of three miles by double-handling from the railway terminus to the batching plant on the left bank, which will involve extra cost. The Project Authorities were transporting cement in bags by road upto the batching plant at a cost of about Rs. 3 per ton, before the railway line was completed. The Team observes that the cement could have been conveniently and economically brought in bulk cement carriers by road and construction of the railway line costing Rs. 50 lakhs could have been avoided.

11.6.2. A road bridge has been constructed on the down-stream side of the Dam with a road width of 38 feet at a cost of about Rs. 36 lakhs against a normal width of 22 feet for a highway road bridge. The extra width of 16 feet was provided for two narrow gauge lines which are not likely to be used. The normal width of 22 feet would have been adequate for all the traffic that is required between the two banks.

11.6.3. Five separate colonies have been constructed which are rather scattered far apart. The Team considers that the lay-out of the colonies for large projects should be compact as far as possible so that the expenditure on services like lighting, water-supply, roads and sanitation etc. can be kept down to the minimum.

11.6.4. The savings of Rs. 70 lakhs in the special tools and plant assumed in the revised project on account of use of some old machinery received from the project is not likely to materialise.

11.6.5. The total cost of machinery purchased to end of 1958-59 amounts to Rs. 5.45 crores of which the earth moving machinery amounts to Rs. 3.56 crores. The average daily utiliastion of machinery for the years 1957-58 and 1958-59 for which data are obtained from

the reports prepared by the Project Authorities and submitted to the Control Board is as under :—

Name of work	1957-58 Hours per working day	1957-58 Minutes per working day	1958-59 Hours per working day	1958-59 Minutes per working day
Dam	2	13	3	04
Right Bank Canal	2	11	1	34
Left Bank Canal	2	33	1	07

The Project Authorities have since suggested that an allowance should be made for rainy days and for days the machines were not in commission. On the basis of the revised statements supplied by the Project Authorities, the average daily utilisation of machinery is as under :—

Name of work	1957-58 Hours per working day	1957-58 Minutes per working day	1958-59 Hours per working day	1958-59 Minutes per working day
Right Bank Canal	4	23	5	33
Left Bank Canal	3	11	3	30

There is scope for improving the overall working efficiency specially by working two shifts. At present the machinery is worked for one shift only.

11.6.6. It may be mentioned that the earth moving machinery involves considerable capital cost and on account of shortage of foreign exchange, it is very scarce. It should, therefore, be utilised to the best advantage. Such machinery should be worked at least in two shifts. The Team recommends that the greatest caution should be exercised in purchasing further machinery for this Project particularly earthmoving machinery.

11.6.7. There are considerable delays in procurement of spare parts due to difficulty of foreign exchange, which prevent full use being made of the machinery. This has been noticed by the Team in their study of other projects also. It is suggested that the necessary steps should be taken at the highest level to avoid costly and scarce machinery remaining idle for lack of spares.

11.6.8. At present the hire charges are based on the norms recommended in the Cost and Rates Committee's Report for the purpose of debit to works, but the poor working efficiency will result in the actual costs being higher per unit rate of output of earthwork.

VII—Phasing of Construction Programme

11.7.1. The First phase of Nagarjunasagar Project estimated in 1956 to cost Rs. 86.57 crores was to be completed by 1963-64 and the phased expenditure was Rs. 1.11 crores, 57.4 crores and 28.06

crores in the First, Second and Third Five Year Plans. The allocation of funds to the Project in the Second Five Year Plan is, however, expected to be only Rs. 37.98 crores. On account of the reduced allotment for the Second Five Year Plan the construction programme has had to be modified and the Project is now expected to be completed not before 1965-66.

11.7.2. The total quantity of masonry in the Dam to be done in the approved First Phase is 160 M.C. Feet of which 36 M.C. Feet has been done by the end of 1959-60. In order to complete the remaining quantity of masonry within the Third Plan, the average annual output will have to be 24 M.C. Feet. As there will be restricted space available for laying masonry specially in the last two years, the peak annual out-turn for next three years will have to be 30 M.C. Feet, which should be aimed at.

11.7.3. The construction of the masonry of the Dam will be the controlling factor in the completion of the Project. Because of the high level of the take-off of Canals, irrigation benefits will start accruing on them only when the Dam is nearing completion. Therefore, in allocating funds for the various units of work on this Project, the Dam should receive preference.

VIII—Power Development

11.8.1. No hydro-electric power is envisaged in the First Phase. The 1954 Project envisaged an ultimate development of 75 MW of firm power at 60 per cent load factor. For this purpose five penstocks of 10 feet diameter were provided. The firm power potential is determined by the discharge required for the second crop irrigation in the Delta in the non-Monsoon months. This is approximately 2,250 cusecs. When no water is required for irrigation in the Delta in some fortnights it is proposed to let down about 20 T.M.C. Feet of water annually for firming up power. The power potential has been worked out on this basis in Working Tables III and IV. This varies from 45 MW to about 250 MW at 100 per cent load factor. It is now proposed by the Central Water and Power Commission to provide eight penstocks of 16 feet diameter "taking into account all possible eventualities and the possibilty that Nagarjunasagar Station may have to operate at a very low load factor of the order of even 25 per cent in conjunction with future base load nuclear and thermal stations". To utilise eventually the potential of power at Nagarjunasagar for peaking; the present provision for embedding in the masonry of the Dam, eight penstocks of 16 feet diameter is in order. A provision of Rs. 50 lakhs has been made for the same in the 1956 estimate.

11.8.2. In the First Phase, the masonry of the Dam will need to be constructed to F.R.L. 546 against F.R.L. 525 provided in the First Phase Project as already explained in paragraphs 11.3.2. and 11.3.3. Apart from providing irrigation for the full area of first crop of First Phase and for 1.25 lakh acres of second crop in the Delta, it will result in a power potential varying from 40 MW to 230 MW at 100 per cent load factor. There is shortage of power in the region which

in inhibiting both medium and large scale industrial development. The power potential at Nagarjunasagar can be developed conveniently and very economically as the incremental cost for the Hydro Plant will be about Rs. 400 per KW only. The Team, therefore, recommends the exploitation of this power potential in the First Phase itself by providing a power house with two units of 50 MW each at an approximate cost of Rs. 4 crores. 132 KV transmission lines from the power house to the two main load centres at Hyderabad and Vijayawada and necessary sub-stations and sub-transmission lines will be required in the first instance to utilise the power; the additional cost for these will be about Rs. 4 crores.

11.8.3. Additional expenditure to develop 100 MW power at Nagarjunasagar and to distribute it, may, therefore, amount to Rs. 8 crores or Rs. 800 per KW. This will cost approximately Rs. 80 per KW year at the main receiving sub-stations. If bulk power is priced at the receiving station at 3.25 nP per KW hour, at which it can be readily marketed at present, the gross revenue that can be realised will be Rs. 171 per KW year at a load factor of 60 per cent. This will give an extra net revenue of Rs. 70 lakhs per annum, which will help materially to augment the total earnings from the First Phase Nagarjunasagar Project. At the same time it will permit phasing to later stages, building of relatively costlier thermal power capacity or exploiting other hydro power potentials; in the latter case funds will be necessary for civil works (Dams) as well as for the Hydro-Power Station.

IX—Construction costs and Financial Forecast

11.9.1. According to the 1954 Joint Project Report, the First Phase was estimated to cost Rs. 85.5 crores. However, in September 1954, the two Chief Engineers for Irrigation of Andhra and Hyderabad States indicated the possibility of reducing the outlay on the First Phase to Rs. 75 crores. The irrigated area was shown as 23.6 lakh acres and the revenue return as 5.05 per cent on the net capital. The Planning Commission approved this scheme in February 1955. Soon after the Project was started, it was realised that the estimated cost, irrigation benefits and percentage return could not be adhered to. A fresh estimate amounting to Rs. 86.6 crores was prepared in 1956 and irrigated area was shown as 20.60 lakh acres and percentage return as 2.64 per cent at the end of the 10th year after completion on the basis of 4.5 per cent simple interest. This estimate was also not prepared in detail, but was more or less based on 1954 Project estimate. On account of increase in cost of cement, steel and oil, this estimate has been further revised to Rs. 91.12 crores. This estimate also does not take into account the important changes made in the design etc.

11.9.2. The working rates for dam masonry and concrete do not allow for sufficient depreciation on special tools and plant purchased and do not take into account actual working expenses for machinery and services like water-supply, lighting, sanitation, huttings etc. The earthwork rates for earthen flanks of the dam are also likely to be exceeded. It is, therefore, necessary that a revised estimate for the

Dam incorporating all the changes made in the designs may be prepared at the earliest possible date on the basis of the actual working rates.

11.9.3. On the basis of the estimates of earthwork for the portion of the Right Bank Canal from head to mile 45 which have been prepared by the Project Authorities, the Team anticipates that there is likely to be some excess on the earthwork for the length of the Right Bank Canal to be done in the First Phase. The Project Authorities anticipate that there will be an excess of ten percent in earthwork and rock excavation quantities.

11.9.4. In the revised estimate amounting to Rs. 91.12 crores the provision for cross drainage works on the two canals has been increased by Rs. 72 lakhs. Even this increased provision is likely to prove inadequate, as there is already an excess of over Rs. 32 lakhs on the four masonry works for which estimates have been sanctioned so far. For the delta area there is a provision of Rs. 100 per acre for distribution system in the revised estimate. The provision for this item on the Right Bank Canal is Rs. 82 per acre of ayacut and that in the case of the Left Bank Canal is only Rs. 50 per acre, which is likely to be exceeded. The Project estimate should again be reviewed and revised early in order to give a clear picture of the overall excess anticipated on this Project.

11.9.5. The 1956 Project showed a return of 2.64 per cent at the end of the 10th Year after completion with the Project cost of Rs. 86.56 crores. It was based on assumptions which were too optimistic. These have been somewhat modified in the new financial forecast for the revised project cost of Rs. 91.12 crores. The return now expected is 2.3 per cent at the end of tenth year after completion decreasing progressively thereafter. The actual position may be somewhat worse if, as is feared, the working expenses come to more than Rs. 2 per acre and the full irrigation development takes more than four years allowed for in the financial return.

11.9.6. The Team makes the following suggestions for improving the financial return :—

(*i*) increase from Rs. 7.50 per acre to Rs. 12 per acre in water-cess for second crop paddy for which the entire water is to be provided from expensive storage;

(*ii*) reduction in percentages of wet crops and increase in percentage of dry crop which will bring more revenue for the same quantity of water;

(*iii*) a uniform rate of Rs. 10 per acre as water-cess for dry crops on both the Canals instead of Rs. 7.50 per acre on the Left Bank Canal and Rs. 10 per acre on the Right Bank Canal;

(*iv*) exploitation of power potential in the First Phase which will give an extra revenue of Rs. 70 lakhs;

(*v*) as the second crop requires water entirely from expensive storage and as very much more revenue can be realised

from non-paddy rabi crops than from second paddy for the same quantity of water, it would be desirable to develop non-paddy rabi crops as far as possible; and

(*vi*) revision of the existing low water-cess rates in the Delta, on account of making assured supplies available from Nagarjunasagar Reservoir.

11.9.7. The Team is of the view that the Project Authorities are in a position to spend much more than what is being allotted annually. The Team, therefore, suggests that the available funds in the Third Five Year Plan should in the first instance be concentrated on this Project in preference to new projects in the State so that this Project will start giving irrigation benefits at an early date.

X—Irrigation Development and Agricultural Aspects

11.10.1. The irrigation demands, duties and rates of water cess provided by Hyderabad and Andhra were on different basis. Now that the whole area lies in the reorganised Andhra Pradesh, it would be desirable to have uniformity as far as possible.

11.10.2. Some cotton is grown in the ayacut area on natural rainfall but it gives very poor yield. If its sowing is done a month or two earlier before rains come—say April-May—with the help of canal water, the yield would increase considerably as has been the experience in Punjab and elsewhere and this should be tried by the State Agriculture Department. In about 75 per cent of the years there will be some extra water available from the storage over and above the requirements of assured irrigation. Some of this can be used for early cotton sowing and green manure crops for improving the poor fertility of the soil. Even in the remaining 25 per cent of the years it should be possible to provide some water for early cotton with slight adjustment in the pattern of wet and dry crops on the two Canals.

11.10.3. The present plan of the Project Authorities in localising the ayacut is to omit the areas at the ridges i.e. areas adjoining the distributaries and to provide irrigation to the low lying areas adjoining the nalla banks. The main consideration by the Project Authorities appears to be that salts from upper lands under irrigation will be leached and carried down to lower lands and thereby ruin lands below by water-logging and increase in salinity, whereas the lands lower down would be easily drained by the natural drainage system, when irrigation is applied there. However, this approach of the Project Authorities appears to overlook the following important considerations :—

(*i*) the areas near the ridges being relatively flat are easily adaptable to flow irrigation without much need for levelling;

(*ii*) the salt contents of soil at ridges do not appear to be high, probably because of continuous drainage by rainfall over a long period.

(*iii*) cultivation of deep rooted plants like fruit trees etc., would not only utilize the sub-soil water but also help in preventing rise of salts to the surface;

(*iv*) application of canal water to low lands would result in a heavy loss of water due to seepage into nallas whereas water applied to upper lands would get stored in the sub-soil of the lower lands and would be available for lift irrigation; and

(*v*) precluding ridge lands from irrigation would involve long lengths of water course for irrigating more distant low lands, thus increasing water losses. Apart from these considerations, the unpleasant task of acquiring land from the land-owners on the ridges and at the same time depriving them of irrigation facilities will be avoided.

Therefore, the Team suggests that these factors should be given full consideration before the lands adjoining the distributaries on the ridges are deprived of irrigation benefits.

11.10.4. The Team suggests that the lands lower down the distributaries adjoining the natural drainages should be reserved for lift irrigation by making use of the sub-soil water, which is already high enough and which will rise still further due to irrigation in the upper lands. This would prevent water-logging of the lower lands in addition to maximising irrigation benefits. To encourage lift irrigation, the Team recommends liberal loans for digging of wells and installing pumps etc., and lower water rates on such irrigation.

11.10.5. As an Anti-malarial measure, the Project Authorities intend precluding from irrigation areas within two miles of each town and half a mile of each village. Lands around towns and villages are not only very expensive but are also generally fertile and can readily bear betterment levy. Such lands are ideally suited for growing vegetables, fodder crops and fruit trees—the latter are also known to minimise the rigours of extreme heat. The Team, therefore, suggests that such areas should be given light irrigation, and only heavily irrigated crops like sugar-cane and paddy should be debarred.

11.10.6. The present plan for localisation of irrigated area envisages permanently ear-marking different areas for (a) wet cultivation or heavy irrigation such as rice, (b) semi-wet or dry cultivation (crops requiring light irrigation) and (c) areas left out of irrigation. Such a step might give rise to resentment among the cultivators denied irrigation or permitted only light irrigation for all times to come. Secondly, no crop rotation would be possible under this system. The Team suggests that the irrigation area of each village may be divided into three parts, two parts for dry and one for wet in a particular season but crops being rotated in every season.

11.10.7. Change over from dry cultivation to wet cultivation brings about revolutionary changes, not only in agricultural economy and pattern, but even in the methods of cultivation and agricultural practices etc. Necessary experimental work has to be undertaken to find

solutions to the numerous problems that will face the cultivators with the advent of canal irrigation. While it is gratifying to note that the Agricultural Department is fully alive to this problem and the Project Authorities are also very keen in the matter and there also exists a Development Committee, much headway has not yet been made in starting the experimental work. As it takes years of experimentation, before authentic results become available, the Team recommends establishment of at least two experimental stations forthwith—one on the Right Bank and the other on the Left Bank Canal, to carry out experiments regarding varietal trials on important crops like paddy, sugarcane, cotton etc., manurial experiments to find out the nutritional requirements of different crops, cultural practices, water requirements of different crops and varietal trials of fruit trees etc. Apart from this, demonstration farms would also be necessary which may be at the rate of one for every twenty-five square miles.

11.10.8. The existing roads in the ayacut are in an unsatisfactory state and are totally inadequate even now. After the development of irrigation, there will be greater need for better roads for transport of the extra agricultural produce. Therefore, the Team recommends that provision of suitable and adequate roads and marketing facilities in the ayacut should be given full and early consideration.

11.10.9. The Team suggests that the survey of sub-soil water table should be taken up at an early date so that timely remedial measures can be taken in the 'danger zones' against water-logging.

11.10.10. The Team is glad to record that the Project staff is working with a fine team spirit.

A. N. KHOSLA
Leader

22nd July, 1960.

APPENDICES

*Prepared by Project Authorities.

APPENDIX I

NAGARJUNASAGAR PROJECT

SALIENT FEATURES AT A GLANCE

1. *General Data*

Location of the Dam site .. .. .. Lat. 16°—34′N
Long. 79°—19′E

Situated at 1¼ mile downstream of Nandikonda village, Miryalguda Taluq, Nalgonda District.

2. *Hydrology*

(*i*) Watershed area at damsite	—	80,000 sq.miles
(*ii*) Mean annual rainfall in the watershed	—	35″
(*iii*) Mean annual run off at Damsite at present	—	1496 TMC Feet (34·34 M.A.Feet)
(*iv*) Max. Flood discharge (estimated) ..	—	10,88,500 cusecs.
(*v*) Max. Flood discharge (observed) ..	—	10,60,880 ,,
(*vi*) Observed Minimum Dry Weather flow	—	100 ,,

3. *Reservoir*

	Full Plan	Phase Plan
(*i*) Max. Reservoir Elevation	F.R.L. 590	525
(*ii*) Storage Capacity at FRL	9·30 M.A.ft.	5·44 M.A. ft.
(*iii*) Dead storage elevation	490	490
(*iv*) Dead storage capacity	3·94 M.A. ft.	3·94 M.A. ft.
(*v*) Live storage	5·36 M.A. ft.	1·5 M.A. ft.
(*vi*) Water spread area	110 sq. miles	73·66 sq. miles

4. *Masonry Dam*

A. **Spillway Dam**

(*i*) Average height above foundation level		302 ft.
(*ii*) Top of Dam Elevation	Plus	560
(*iii*) Top of Crest Elevation	,,	520
(*iv*) Top of Crest Gates Elevation.. ..	,,	525
(*v*) River Sluice Invert Elevation	,,	435·5
(*vi*) Construction sluice invert elevation		295·5
(*vii*) Length of Spillway		1880 ft.
(*viii*) Level of Bucket Floor in Rear of Dam		235 ,,
(*ix*) Maximum flood discharge capacity provided—Crest	—	10,27,350 cusecs.
(*x*) River sluices	—	20,000 cusecs (minimum)
	Total	10,47,350 cusecs

APPENDIX I (*contd.*)

B. Non-Overflow Dam			*feet*
(*i*) Length of non-overflow masonry dam.			
Left flank			1,380
Right flank			640
(*ii*) Length of the composite dam			
Left flank			1,740
Right flank			3,220
5. *Earth Dam*			
(*i*) Location: On Hyderabad side in gap left of the river gorge.			
(*ii*) Length of the dam			3,800
(*iii*) maximum height of the dam			35
6. *Power Plant* (for full plant)			
(*i*) Centre line of Penstock elevation ..	Plus	373	To be finalised.
(*ii*) Size of penstocks	—	10 ft. dia.	
(*iii*) No. of penstocks	—	5 Nos.	
(*iv*) Centre line of unit elevation	Plus	244	
(*v*) No. and size of units 5 Nos. ..	—	20,000 KW each	
(*vi*) Spacing of units	—	35′	
(*vii*) Proposed installed capacity	—	1,00,000 KW	
(*viii*) Average head for power development	—	305 ft.	
(*ix*) Anticipated firm power at 60% load factor	—	75,000 KW	
7. *Right Bank Canal* (*Andhra side*)			
(*i*) Sill of the offtake channel	Plus	490	
(*ii*) FSL discharge	—	11,000 cusecs	
(*iii*) Rugosity coeff. in Mannings formula :—			
(*a*) for lined main canal	—	0·018	
(*b*) for unlined canal	—	0·0225	
(*iv*) Side slopes	—	1 : 1	
(*v*) Maximum velocity lined	—	6 ft./sec.	
Maximum velocity unlined	—	3·5 ft./sec.	
(*vi*) Section for maximum discharge			
Bed width.	—	250 ft.	
Depth { 1st phase	—	11·8 ft.	
Depth { Ultimate	—	15·0 ft.	
(*vii*) Length of the canal upto Musi ..	—	135 miles	
8. *Left Bank Canal* (*Hyderabad side*)			
(*i*) Sill of the offtake channel	Plus	490	
(*ii*) FSL discharge	—	11,000 cusecs.	
(*iii*) Rugosity coeff. in Manning's formula for lined main canal	—	0·018	
(*iv*) Side slopes	—	1½ : 1	
(*v*) Maximum velocity	—	6 ft./sec.	

APPENDIX I (*contd.*)

(*vi*) Section for maximum charge.		
Bed width	—	134 ft.
Depth	—	15 ft.
(*vii*) Length of the canal	—	108 miles.

9. *Ayacut*

A. **Right Bank Canal (Andhra) F.R.L.**	Full plan 590·00	Phase plan 525·00
	lakh acres	lakh acres.
(*i*) In Guntur and Nellore Dists. First Crop 1/3 wet and 2/3 dry.	14·70	7·70
(*ii*) Under Pulichintala block First Crop 1/3 wet and 2/3 dry	2·00	2·00
(*iii*) Kavali canal wet	1·10	—
Kanupur canal wet	0·78	—
TOTAL ..	18·58	9·70
B. Left Bank Canal (Hyderabad and Andhra)		
(*i*) Hyderabad First crop	6·75	5·40
Second crop	1·20	1·20
(*ii*) Andhra (Nandigama Taluq) 1/3 wet 2/3 dry	2·05	1·30
TOTAL ..	10·00	7·90
C. Krishna Delta		
	lakh acres	lakh acres
(*i*) Extra crops ensuring supplies for 10·5 lakhs of existing irrigation	1·50	1·50
(*ii*) II crop in Krishna Delta	1·50	1·50
(*iii*) Perennial	0·25	—
TOTAL ..	3·25	3·00

Total Ayacut (In Lakh Acres)

	Full Plan		Phase Plan	
	I Crop	II crop & Perennial.	I crop	II crop
Andhra	22·13	1·75	12·50	1·5
Hyderabad	6·75	1·20	5·40	1·2
TOTAL ..	28·88	2·95	17·90	2·7
GRAND TOTAL ..	31·83 lakh acres		20·60 lakhs acres	

10. *Estimated Costs*

	Full Plan	Phase Plan
F.R.L.	590·00	525·00
	Rs. crores	Rs. crores
Unit 1. Dam	34·72	33·84

APPENDIX I (*concld.*)

Unit 2. Right Bank Canal		61·10	30·94
Left Bank Canal		26·20	23·40
	Total	122·02	88·18
Financial returns ten years after completion		4·23% (with 3·75% interest)	3·06% (with 4·75% intrest)
Unit 3.			
Estimated cost of power plant and transmission		8·71 crores	
Financial return including power		5·60%	

APPENDIX II

Yields of Krishna at Srisailam and Nagarjunasagar.

With a view to determine the availability of water for the new projects at Srisailam and Nagarjunasagar it is necessary to work out the yield in different reaches for dependable year on which allocations to various States are based. These yields have been worked out in 1954 project and are based on Khosla's formula for run off. A statement which gives the catchment area, the annual rainfall and the yield in million acre feet in different reaches of Krishna catchment for a normal year is given below :—

Sl. No.	Name of River	Catchment area in sq. miles	Normal rainfall inches (Annual)	Mean Temperature Degree F° (Annual)	Loss inches (Annual)	Run-off inches (Annual)	Runoff M. Acre ft. (Annual)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	Krishna upto Bhima (excluding Bhima)	20,938	36·51	76·40	23·50	13·01	14·53
2.	Bhima	26,335	30·67	78·90	24·26	6·41	9·00
3.	Tungabhadra upto dam-site.	11,121	40·31	76·50	27·67	12·64	7·50
4.	Tungabhadra from dam-site to its confluence with Krishna.	15,877	22·58	79·06	22·43	0·15	0·13
5.	Rest of Krishna:						
	(*a*) From its confluence with Bhima to Siddheswaram.	4,142	26·66	—	21·65	5·01	1·11
	(*b*) From Siddheswaram to Nandikonda.	4,674	25·40	—	21·60	3·80	0·91
	(*c*) From Nandikonda to Pulichintala.	7,563	28·69	—	22·75	5·94	2·36
	(*d*) From Pulichintala to Vijayawada.	6,400	30·09	—	23·77	7·32	2·47
	Total of Krishna at Vijayawada	97,050					38·01 Say 38·00

On the basis of this statement the yield of Krishna river between Srisailam and Vijayawada works out to 15% and between Srisailam and Nagarjunasagar 2.25%. These percentages have also been adopted in the report of the Technical Committee for the optimum utilisation of the Krishna and Godavari waters (1953). This question

APPENDIX II (*contd*)

was discussed in a meeting held by the Team with C.W. & P.C. on 23rd June, 1959. A statement given by the C.W. & P.C. showing the yield of river Krishna in a dependable year at various points and the available yield after allowing for the upstream projects and dependable yield at Nagarjunasagar after allowing for the upstream projects is given below :—

Item	Supplies in *T.M.C.Ft.*
1. Dependable yield at	
(*i*) Vijayawada anicut	1715·0
(*ii*) Pulichintala dam	1603·0
(*iii*) Nandikonda dam (Nagarjunasagar Dam)	1496·0
2. Existing utilisation (1951)	
(*i*) Delta irrigation	200·0
(*ii*) U/s of Nagarjunasagar	209·0
(*iii*) D/s of Nagarjunasagar	56·0
Total as per 1951 Award	465·0
3. Projects under construction (1951) u/s of Nagarjunasagar dam.	280·0
4. Balance for future projects	
(*i*) Bombay	145·5
(*ii*) Mysore	255·0
(*iii*) Andhra	570·0
TOTAL ..	970·5
5. Future projects u/s of Nagarjunasagar in Andhra	61·5
6. Supplies available at Nagarjunasagar on the basis of 1715 T.M. C.Ft. as dependable yield at Vijayawada =dependable yield—U/s utilisation=1496—(209+280+145·5 +255+61·5)=1496—951=545	545·0
7. Supplies available at Nagarjunasagar on the basis of 1745 T.M. C.Ft. as dependable yield at Vijayawada anicut. =dependable yield—U/s Utilisations =1525—(209+280+149·5+263+61·5) =1525—963·0=562 T.M. C.Ft.	562·0

From this statement it will be seen that the yield available at Nagarjunasagar in a dependable year is 562 T.M. C.Ft. This has since been confirmed by the Chairman, C.W. & P.C. in his D.O. No. M.(P&I)/NS, dated 5-12-59 (Appendix No. II-A). The yield between Siddheswaram and Nagarjunasagar after allowing for the existing projects of 4 T.M, C.Ft. works out to 35 T.M. C.Ft. The net yield in a dependable year at Siddheswaram works out to 562—35=

APPENDIX II (*concld*)

527 T.M. C.Ft. The demand at Nagarjunasagar for irrigation and power in the final phase is as under :—

	T.M.C.Ft.
Right Bank Canal	222
Left Bank Canal	186
Delta irrigation from Nagarjunasagar Reservoir	111
Evaporation losses	16
Firming up of power	20
Total	555

These demand figures have been accepted both by the C.W. & P.C. and the Project Authorities.

There is thus just sufficient water for final phase irrigation and firming up power on the basis of dependable yield shown in 1951 Award.

The yield of river Krishna at Vijayawada for a year of 75% dependability works out to about 1,700 T.M. C.Ft. In 1937-38 the yield of river Krishna was about 1,706 T.M. C.Ft. and this year, we have taken as the year of 75% dependability for which we prepared working tables. The C.W. & P.C. have also taken this year as of 75% dependability.

The total extra yield over and above the dependable inflows works out to 1706—1480=226 T.M.C.Ft. The share of Andhra State out of surpluses due to reorganisation of States has been worked out by C.W. & P.C. at 53.5%. The share of Andhra State out of the surpluses would be 121 T.M. C.Ft. The extra yield between Srisailam and Vijayawada at 15% of total =0.15 x 226=34 T.M. C.Ft. The yield available at Srisailam works out to 527+121 – 34=614 T.M. C.Ft.

APPENDIX II-A

*STATEMENT SHOWING THE DISCHARGES AVAILABLE AT NAGARJUNASAGAR

			TMCFt.
1.	The dependable yield of Krishna river at Vijawawada was for allocation amongst the States accepted as	=	1745
2.	Water utilisation upstream of Nagarjunasagar		
	(*i*) Projects under operation in 1951	=	206·0
	(*ii*) Projects under construction in 1951	=	280·0
	(*iii*) Future projects as per allocated share of the States of Bombay and Mysore (worked out in the Commission)	=	412·5
	(*iv*) Future projects included in the Plans by Andhra State:		
	(*a*) Remodelling of K.C. Canal .. 27·0		
	(*b*) T.H.L. Canal .. .. .. 32·5		
	(*c*) Bhairvaniti .. .. .. 2·0	=	61·5
	Total Item 2	=	960·0
3.	Dependable flow available between Nagarjunsagar and Vijayawada at 12·75% as given in the 1954 Joint Report (12·75% of 1745)	=	223·0
4.	Total dependable yield at Nagarjunasagar (on the basis of accepted dependable yield of 1745 TMCFt. at Vijayawada) (1745—223)	=	1522·0
5.	Balance available at Nagarjunasagar (1522—960)	=	562·0

*Received under D.O. No. M(P&I)/NS dated the 5th December, 1959 from the Chairman, Central Water and Power Commission to the Irrigation and Power Team

APPENDIX II-B

**Observed Fortnightly Discharges of Krishna River at Vijayawada Anicut*

(ALL UNITS IN T.M.C.FT.)

Periods		1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906
May	II	0·2	1·2	0·4	1·1	4·6	6·7	0·3	18·7	0·9	1·1	1·1	1·8	·0
June	I	5·2	1·9	28·3	18·2	15·6	16·7	6·0	21·0	6·8	5·5	8·1	4·9	—
	II	65·3	39·2	160·5	124·3	158·1	86·1	71·6	83·6	37·6	49·5	93·0	25·9	95·9
July	I	91·3	104·2	215·9	67·8	133·4	123·5	275·2	184·2	50·7	94·7	416·8	67·6	103·1
	II	658·2	198·7	364·1	359·1	473·8	154·7	502·3	366·1	418·7	546·8	202·9	252·1	314·6
Aug.	I	185·3	417·2	796·1	460·3	446·8	43·9	611·3	427·4	175·3	570·6	182·4	234·6	231·5
	II	230·6	190·3	542·3	404·1	177·9	80·9	575·8	399·2	72·8	305·6	174·8	189·0	290·7
Sept.	I	155·0	284·7	89·2	210·7	231·4	102·7	141·7	119·5	309·6	210·6	51·6	101·7	320·6
	II	150·7	262·3	35·1	240·1	216·9	211·1	109·2	105·5	286·8	322·8	198·5	65·6	154·9
Oct.	I	71·9	181·0	33·9	321·9	268·3	24·5	128·6	87·2	50·9	506·2	43·5	30·5	72·4
	II	88·0	98·7	30·2	115·5	71·4	13·1	35·5	34·4	89·7	114·3	107·0	55·8	50·3
Nov.	I	75·2	103·6	15·7	62·8	38·9	7·7	14·8	24·9	70·0	75·3	24·8	15·3	14·7
	II	24·3	24·1	18·8	36·7	47·5	3·3	7·3	10·2	23·1	36·2	8·3	5·1	10·5
Dec.	I	15·1	12·9	19·6	11·2	14·3	1·9	4·1	5·2	36·3	35·3	4·3	3·1	5·1
	II	5·8	9·7	4·8	4·3	8·6	1·6	3·8	3·3	62·2	13·4	3·9	2·9	7·5
Jan.	I	4·5	6·5	2·5	3·3	4·6	1·3	2·5	2·4	11·5	6·1	2·6	2·0	16·8
	II	4·1	5·1	2·3	2·6	3·2	1·2	2·2	2·0	8·4	3·1	2·4	2·1	4·4
Feb.	I	2·2	3·3	1·5	2·0	2·3	0·9	2·4	1·4	3·1	2·4	0·7	2·8	2·1
	II	1·8	4·0	1·5	1·7	2·0	0·8	8·0	1·6	2·1	2·1	0·3	2·1	1·8
March	I	1·3	3·4	0·8	0·8	1·7	0·8	4·6	0·8	1·5	1·5	0·2	1·6	1·7
	II	1·4	3·0	—	0·8	1·7	0·6	1·9	0·8	1·3	1·0	0·2	0·9	1·4
Apr.	I	0·1	1·4	—	—	1·0	0·3	1·0	0·5	0·8	0·6	0·1	0·3	1·2
	II	—	1·2	—	—	8·5	0·6	0·2	0·2	0·8	0·5	0·2	0·2	1·0
May	I	—	0·4	1·6	5·7	7·5	0·4	21·0	0·2	0·6	0·4	0·1	0·1	15·0
		1837·5	1958·0	2365·1	2455·0	2340·0	885·3	2531·3	1900·3	1721·5	2905·6	1527·7	1068·0	1699·2

*Daily Data supplied by Chief Engineer, Electricity Projects, Andhra Pradesh.

Periods		1907	1908	1909	191 0	1911	1912	1913	1914	1915	1916	1917	1918	1919
May	II	3·3	0·3	3·4	—	0·2	1·7	1·4	0·1	4·7	0·1	1·4	20·4	1·6
June	I	2·0	0·6	6·6	—	4·6	3·0	50·2	0·6	5·3	53·2	44·0	38·2	82·4
	II	34·1	3·2	52·4	6·7	86·5	5·3	109·3	28·4	22·3	78·1	101·3	13·3	54·5
July	I	103·0	168·0	204·1	299·5	103·9	57·5	250·9	128·8	296·4	220·5	172·5	58·1	173·8
	II	246·5	489·5	489·4	98·7	255·2	348·1	325·9	599·4	170·8	260·0	165·9	40·9	130·9
Aug.	I	575·1	498·0	437·8	260·1	163·5	560·6	389·3	824·3	490·0	512·9	246·8	76·2	377·4
	II	501·9	258·6	180·7	304·6	252·6	268·4	91·3	352·7	154·8	351·4	240·3	206·7	185·3
Sept.	I	152·1	185·8	279·3	229·4	145·5	113·2	104·6	162·6	126·4	256·2	460·8	101·7	250·0
	II	95·8	382·8	74·1	272·4	90·8	128·8	66·3	376·6	226·4	372·7	290·7	134·4	193·8
Oct.	I	158·3	116·5	90·1	271·6	38·0	105·8	64·7	143·8	388·4	97·5	234·5	34·0	270·0
	II	25·6	24·8	36·6	155·3	39·0	84·1	91·2	33·8	109·0	209·5	332·5	10·4	71·1
Nov.	I	11·0	14·9	13·1	102·1	11·9	32·8	13	19·2	74· 8	715·4	105·3	6·5	50·2
	II	8·6	7·8	8·4	38·2	7·2	14·2	7·0	13·5	31·7	150·5	133·4	12·2	66·7
Dec.	I	7·2	4·2	5·3	15·4	7·1	15·1	4·2	8·1	13·9	59·9	45·3	23·3	13·4
	II	5·6	3·8	4·3	11·0	7·3	8·9	3·6	8·5	9·2	41·4	23·4	7·7	10·9
Jan.	I	4·4	3·3	3·0	6·9	1·5	5·3	0·6	11·9	7·9	29·0	12·2	2·7	5·3
	II	3·8	2·9	1·6	5·8	0·5	1·9	—	10·5	6·1	19·9	11·6	1·9	4·4
Feb.	I	2·0	1·9	0·2	3·4	—	0·6	—	6·1	3·3	16·5	7·5	1·3	3·3
	II	1·7	1·7	—	2·3	—	—	—	2·5	3·1	9·7	4·4	0·5	2·0
March	I	1·5	1·6	—	0·9	—	—	—	7·4	4·4	6·3	3·8	0·3	1·0
	II	0·9	1·2	—	1·2	—	—	—	4·5	1·3	3·8	1·8	0·3	0·3
April	I	1·1	1·5	0·6	0·8	—	0·5	2·2	1·3	0·5	2·7	1·5	0·8	0·4
	II	0·8	1·3	0·2	0·4	0·1	0·3	0·6	0·5	0·2	2·7	1·4	0·3	0·5
May	I	—	0·9	0·0	0·2	1·0	—	0·3	1·1	0·1	1·9	0·7	4·4	
		1946·3	2175·1	1892·2	2086·9	1216·4	1755·5	1577·1	2746·2	2151·0	3471·8	2643·0	796·5	1949·2

APPENDIX II-B (*contd*)

Periods		1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932
May	II	0·8	0·3	1·3	0·7	0·2	43·4	3·1	0·2	0·9	4·7	—	0·9	0·8
June	I	0·4	6·2	16·3	1·4	3·0	8·6	1·8	1·8	24·8	7·6	2·3	12·3	10·9
	II	44·5	32·5	19·4	3·0	22·7	17·8	7·5	56·7	48·4	46·5	22·9	39·0	15·3
July	I	178·3	29·6	235·8	116·0	22·1	193·5	158·1	157·7	89·7	199·4	270·0	148·2	63·8
	II	395·5	237·3	351·3	569·0	521·0	511·7	199·9	454·7	195·9	339·2	284·5	367·2	398·9
Aug.	I	284·3	472·9	335·5	507·9	342·4	265·6	507·3	344·6	332·1	185·9	308·3	294·9	511·7
	II	127·4	326·5	212·7	347·4	186·1	236·5	393·1	244·2	197·0	185·4	182·9	539·4	226.6
Sept.	I	67·5	114·5	130·2	132·1	344·8	149·7	243·1	169·6	307·3	119·6	195·6	262·8	323·9
	II	124·6	174·3	93·1	200·0	196·0	97·4	215·8	239·3	247·7	163·6	235·1	261·3	172·3
Oct.	I	100·4	166·3	67·7	85·2	147·6	191·9	108·0	182·6	273·2	304·7	157·4	260·7	101·8
	II	28·0	90·7	47·9	26·6	47·5	103·8	37·7	42·2	102·3	60·1	85·3	137·8	179·7
Nov.	I	9·0	93·3	86·6	15·9	20·1	13·8	11·6	46·6	49·1	16·2	100·7	79·9	199·3
	II	5·2	16·7	95·4	6·1	11·1	13·9	7·7	66·8	13·0	12·0	31·2	63·7	61·9
Dec.	I	2·8	7·1	40·9	3·6	6·5	6·9	4·9	10·4	8·9	6·1	10·1	22·4	26·2
	II	2·2	4·2	9·4	2·5	5·5	6·0	2·5	5·8	5·9	4·4	4·8	13·6	13·9
Jan.	I	1·4	4·6	3·9	1·6	2·7	3·3	1·6	4·0	4·7	2·0	3·6	8·2	8·2
	II	1·4	4·8	2·4	1·2	1·7	2·0	1·3	2·2	3·2	1·2	2·2	4·7	5·9
Feb.	I	0·9	1·9	1·6	0·7	1·1	2·7	0·7	2·0	2·1	0·4	1·0	1·7	4·0
	II	0·7	1·2	1·0	0·4	0·6	2·2	0·5	2·4	2·1	0·2	3·0	0·4	3·0
March	I	0·8	0·7	2·4	0·3	0·5	3·4	0·3	1·4	1·5	—	0·2	1·7	2·9
	II	0·8	0·2	1·6	0·1	0·5	0·8	0·3	0·9	1·3	0·4	0·6	1·5	2·0
April	I	—	0·2	1·5	—	0·5	1·7	0·2	1·0	0·9	0·2	0·4	1·1	1·5
	II	0·1	0·1	2·8	—	1·8	0·3	—	0·8	0·8	0·3	0·2	0·9	6·0
May	I	1·9	0·1	0·8	0·1	6·8	0·2	—	0·4	3·4	0·1	—	0·2	6·8
		1378·8	1786·2	1761·5	2021·8	1892·8	1876·1	1907·0	2038·3	1916·2	1660·2	1902·3	2524·5	2347·3

Periods		1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945
May	II	24·4	0·8	—	3·3	1·7	0·2	—	72·7	2·2	0·8	58·7	1·0	0·3
June	I	48·4	1·2	—	12·0	1·3	30·8	—	8·2	1·6	9·2	23·6	4·8	2·8
	II	78·6	10·3	47·9	14·2	16·2	126·3	25·8	34·0	40·6	90·2	46·4	36·9	12·6
July	I	169·3	268·1	73·7	244·9	153·1	267·5	154·9	206·4	308·1	283·2	168·8	102·3	202·1
	II	232·7	250·6	238·4	239·0	451·5	355·9	408·4	344·6	254·4	298·5	409·6	423·2	352·0
Aug.	I	640·7	294·9	238·0	251·7	315·1	206·8	127·0	301·8	73·4	374·7	266·4	305·0	165·1
	II	253·6	409·4	212·9	238·3	138·6	210·9	233·8	247·9	218·5	199·5	108·1	206·2	307·7
Sept.	I	343·0	147·8	289·6	114·9	47·3	206·3	321·7	140·0	106·1	191·3	216·4	130·4	173·9
	II	283·2	70·0	206·5	155·2	183·0	225·5	146·5	109·4	145·6	63·7	129·9	126·5	99·5
Oct.	I	164·3	83·1	88·9	170·3	268·9	380·2	41·9	102·7	117·4	26·2	208·8	61·1	59·7
	II	225·0	26·8	95·7	64·7	60·7	89·4	124·2	110·7	33·3	33·5	224·3	112·7	71·6
Nov.	I	58·0	95·4	68·2	37·1	35·1	22·3	79·6	31·8	8·9	9·7	47·2	135·0	15·3
	II	58·6	25·9	16·9	65·8	11·0	14·7	23·1	14·6	6·0	6·3	26·0	24·4	10·1
Dec.	I	19·9	10·8	8·2	14·2	5·6	7·5	9·6	12·7	4·7	4·6	13·5	10·8	5·5
	II	20·7	7·8	6·3	6·2	3·8	5·1	5·2	9·8	3·0	4·5	8·5	4·2	3·5
Jan.	I	16·7	5·5	4·6	4·0	3·0	5·0	3·2	5·5	2·1	10·6	7·2	4·0	2·4
	II	7·2	4·5	3·8	2·8	2·0	3·6	2·5	9·8	2·6	5·3	6·4	3·0	2·3
Feb.	I	5·1	4·9	2·9	2·0	1·3	2·4	1·6	5·7	1·7	3·7	4·4	2·2	1·1
	II	3·4	3·1	6·4	3·6	0·7	1·4	0·9	2·4	1·3	2·5	2·8	1·3	0·9
March	I	2·8	1·9	3·5	1·7	0·4	0·8	0·6	1·9	1·6	0·9	2·4	1·0	0·9
	II	2·3	1·2	1·2	0·9	0·2	0·8	0·7	0·6	0·8	0·8	4·3	1·0	0·8
April	I	1·3	2·1	3·3	2·6	2·2	0·6	0·4	0·4	0·5	0·2	3·2	0·5	0·2
	II	2·0	2·6	1·8	16·0	2·1	0·3	0·4	0·3	0·4	0·2	1·2	1·9	0·5
May	I	2·2	1·1	0·5	12·8	0·9	0·1	1·3	—	0·8	—	0·8	1·1	....0·1
		2663·4	1729·8	1619·2	1678·2	1705·2	2164·4	1713·3	1873·9	1335·6	1680·1	1983·9	1700·5	1490·9

APPENDIX II-B (*concld*)

Periods		1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958
May	II	0·4	0·1	11·1	0·3	0·5	0·3	99·7	0·2	2·6	14·3	9·6	7·2	3·1
June	I	29·7	9·1	3·0	12·2	28·2	34·8	30·6	0·2	8·4	19·9	16·4	25·2	12·1
	II	43·3	33·8	18·17	27·6	17·3	48·6	24·0	36·2	14·7	21·5	14·9	36·3	—
July	I	219·3	79·2	93·9	71·1	17·4	132·3	67·9	387·8	131·9	184·9	403·8	165·2	290·5
	II	240·2	297·9	267·4	258·9	495·0	262·3	216·4	236·2	430·6	163·8	720·4	444·0	860·9
Aug.	I	523·7	174·1	253·9	316·6	387·4	335·6	397·6	322·5	424·8	251·9	771·5	282·6	218·2
	II	427·8	386·2	376·3	204·3	197·2	189·6	252·5	453·9	253·6	475·1	304·9	510·3	355·5
Sept.	I	243·3	360·3	136·9	195·1	295·0	134·8	71·4	190·7	198·4	343·5	213·7	203·8	304·5
	II	123·7	332·2	192·1	505·5	230·7	52·6	35·9	185·7	196·0	259·3	152·5	135·1	283·7
Oct.	I	154·1	191·5	181·5	158·1	197·6	150·2	110·9	231·2	153·8	357·6	348·3	59·4	119·3
	II	30·6	106·8	98·5	200·3	151·4	67·8	99·5	229·9	75·7	231·1	254·0	154·5	82·1
Nov.	I	48·9	23·0	54·3	52·5	37·7	21·0	15·0	125·3	32·3	114·4	242·1	81·5	17·7
	II	78·2	15·5	123·9	18·2	17·6	9·0	5·7	24·4	12·7	30·1	104·7	46·6	7·9
Dec.	I	27·4	8·1	60·3	9·8	7·4	8·4	3·7	13·5	10·9	16·4	59·2	19·6	9·8
	II	12·2	8·7	17·4	6·3	5·0	4·5	7·7	9·1	7·2	11·2	25·3	12·7	7·4
Jan.	I	6·9	5·4	8·2	4·9	4·1	2·0	2·0	6·7	7·9	7·0	14·9	n.a.	n.a.
	II	5·9	4·0	6·2	5·0	3·0	1·7	1·3	6·4	5·3	7·3	13·0	n.a.	n.a.
Feb.	I	3·2	2·5	4·5	3·3	2·1	1·4	0·9	4·3	5·3	6·5	10·1	n.a.	n.a.
	II	2·2	1·8	2·8	2·0	1·2	0·9	0·5	4·5	6·3	5·3	7·6	n.a.	n.a.
March	I	1·2	1·3	2·1	1·6	0·9	0·7	0·2	5·1	7·9	5·1	10·2	n.a.	n.a.
	II	1·8	1·2	1·4	1·4	0·9	0·6	0·2	1·2	8·4	4·6	9·7	n.a.	n.a.
April	I	0·3	1·3	1·1	1·3	2·7	0·4	0·2	6·4	7·8	6·8	8·6	5·2	n.a.
	II	0·1	2·0	—	—	—	0·3	1·2	2·0	3·8	6·7	7·4	5·0	n.a.
May	I	—	3·7	—	—	—	0·1	—	2·4	5·2	8·6	6·2	2·8	n.a.
		2224·4	2049·7	1915·5	2056·3	2101·2	1459·9	1445·0	2495·8	2011·5	2552·9	3729·0	2197·0	2572·7

Received under C.W. & P.C. D.O. No. H-114(47)/XXIX/59 dated the 22nd August, 1959.

APPENDIX III

Transfer of 1.5 *lakh acres of First Crop from Delta to Nagarjunasagar Canal*

Minute from XX meeting of Nagarjunasagar Control Board held on 30-12-58.

Item 10 : **Arrangements for early irrigation in Krishna Delta :**

The Board considered that a prior decision regarding the sanction of the Guntur Channel scheme was necessary before consequential arrangements could be examined in relation to the Nagarjunasagar Project. It was agreed that instead of the development of 1½ lakh acres 2nd crop in the Krishna delta as provided in the Project estimate, 3½ lakh acres should be developed from the 4th year of construction. As it was reported that the available area for the development of 1st crop under the Krishna delta had been covered by the Krishna Barrage; it was considered that the extent of 1½ lakh acres 1st crop could be redistributed within the accepted ayacut of the Nagarjunasagar Project.

APPENDIX IV

C.W. & P.C.'s Working Table of Srisailam Reservoir Year 1945-46 (90%)

Month & Period		Starting		Inflow in M. CFt.	Total quantity of water available in M.C.Ft.	Draw off				
		Level in ft.	Storage in M.C.Ft.			Irrigation in M.C.Ft.	Power draft		Evaporation	
							in M.C.Ft.	in cusecs.	inches	in M.C.Ft.
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
July	I ..	854	157554	84653	242207	8103	50000	38500	3	882
	II ..	861	183222	147463	330685	8827	50000	36500	3	1121
Aug.	I ..	879	270737	69154	339891	9659	50000	38500	3	1608
	II ..	880	278624	129217	407841	10343	37000	27000	3	1653
Sept.	I ..	885	308062	72833	380895	7645	37000	28200	3	1655
	II ..	885	308062	41698	349760	2039	38000	29300	3	1655
Oct.	I ..	885	308062	24991	333053	1798	24250	18900	3	1655
	II ..	885	305350	29998	335348	1918	24250	18900	3	1655
Nov.	I ..	885	307525	6414	313939	1543	9300	7150	2	1070
	II ..	884	302026	4325	306351	1596	9300	7150	2	1050
Dec.	I ..	883	294405	2304	296709	389	9300	7150	2	1040
	II ..	881	285980	1460	287440	562	9300	6800	2	1008

Jan.	I	..	880	276578	1004	277582	—	9300	7150	2	963
	II	..	879	267319	956	268275	—	9300	6800	2	944
Feb.	I	..	877	258031	447	2581478	—	9300	7700	2	872
	II	..	875	248306	368	248674	—	9300	7700	2	822
March	I	..	873	238552	385	238937	—	9300	7150	4½	1771
	II	..	871	227866	353	228219	—	9300	6800	4½	1647
April	I	..	869	217272	100	217372	—	9300	7150	6	2040
	II	..	867	206032	217	206249	—	9300	7150	6	1908
May	I	..	864	195041	61	195102	—	9300	7150	6	1745
	II	..	861	184057	108	184165	—	9300	6800	6	1578
June	I	..	859	173287	1163	174450	496	9300	7150	4½	1116
	II	..	856	163538	5281	168819	282	9800	7550	4½	1110
TOTAL		..			624953		55000	459800			32560

APPENDIX IV (*contd.*)

Month & Period		Total draw off in Mcft.	Net storage in Mcft.	Surplus in Mcft.	Reservoir level at the end of the fortnight in ft.	Average Reservoir level in ft.	Tail water level in ft.	Had available		Power output	
								Gross in ft.	Net in ft.	100% L.F. K.W.	60% L.F. K.W.
(I)		(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
July	I ..	58985	183222	—	861	857·5	540·0	317·5	315·5	810000	1350000
	II ..	59948	270737	—	879	870·0	540·0	330·0	328·0	799000	1330000
Aug.	I ..	61267	278624	—	880	879·5	540·0	339·5	337·5	815000	1440000
	II ..	48996	308062	50783	885	882·2	544·0	338·5	336·5	605000	1010000
Sept.	I ..	46100	308062	26733	885	885·0	560·0	325·0	323·0	605000	1010000
	II ..	41694	308062	4	885	885·0	565·0	320·0	318·0	620000	1035000
Oct.	I ..	27703	305350	—	885	885·0	561·5	313·5	311·5	392000	650500
	II ..	27823	307525	—	885	885·0	556·5	328·5	326·5	410000	685000
Nov.	I ..	11913	302026	—	884	884·5	549·0	335·5	333·5	158000	265000
	II ..	11946	294405	—	883	883·5	540·0	343·5	341·5	161500	271000
Dec.	I ..	10729	285980	—	881	882·0	540·0	342·0	340·0	161000	270000
	II	10862	276578	—	880	880·5	540·0	340·5	338·5	158000	255000

Jan.	I	..	10263	267319	—	879	879·5	540·0	339·5	337·5	163000	268000
	II	..	10244	258031	—	877	878·0	540·0	338·0	336·0	156000	260000
Feb.	I	..	10172	248306	—	875	876·0	540·0	336·0	334·0	160000	256000
	II	..	10122	238552		873	874·0	540·0	334·0	332·0	159000	255000
March	I	..	11071	227866	—	871	872·0	540·0	332·0	330·0	157000	263000
	II	..	10047	217272	—	869	870·0	540·0	330·0	328·0	152000	252000
April	I	..	11340	206032	—	867	868·0	540·0	328·0	326·0	155000	259000
	II	..	11208	105041	—	864	865·5	540·0	325·5	323·5	154000	258000
May	I	..	11045	184057	—	861	862·5	540·0	322·5	320·5	152000	255000
	II	..	10878	173287	—	859	860·0	540·0	320·0	318·0	148000	249000
June	I	..	10912	163538	—	856	857·5	540·0	317·0	315·5	148000	249000
June	II	..	11192	157627	—	854	855·0	540·0	315·5	313·0	157000	262000
TOTAL		..	547306		77520							

APPENDIX IV-A

C.W.&P.C.'s Working Table of Nagarjunasagar Reservoir Year— 1945-46 (90%)

Month & Period			Starting		Inffow			Total quantity of water available	Draw off		
									Irrigation		
			Level	Storage	From Srisailam Lake.	Inter-mediate flow between Srisailam & N.S.	Total		Left Bank	Right Bank	Delta
			in ft.	in M.cft.	M.cft.	M.cft.	M.cft.	M.cft.	M.cft.	M.cft.	M.cft.
	(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
July	I	..	530	247505	50000	5	50005	297510	11721	20443	15799
	II	..	531	249019	50000	52	50052	299071	13059	21748	7047
Aug.	I	..	534	256681	50000	233	50233	306919	13511	23062	13779
	II	..	534	256033	67783	3719	91502	347535	12922	25535	6484
Sept.	I	..	554	302025	63733	6479	70212	372227	11052	20742	10302
	II	..	566	329526	38004	3039	41043	370569	10436	21117	11786
Oct.	I	..	564	326645	24250	5677	29927	356572	10436	16854	13868
	II	..	559	314832	24250	3199	27449	342281	8246	20576	10616
Nov.	I	..	554	302270	9300	1823	11133	313403	7732	17620	11620
	II	..	544	276046	9300	1081	10381	286427	1599	19256	9782
Dec.	I	..	533	255408	9300	1319	10619	266027	4115	5326	4000

	II	..	532	251944	9300	283	9583	261527	4746	2220	4250
Jan.	I	..	531	249945	9300	193	9493	259038	4450	—	4000
	II	..	532	250622	9300	103	9403	260025	6527	—	4250
Feb.	I	..	530	248882	9300	65	9365	258247	6121	—	3830
	II	..	530	247932	9300	44	9344	257276	4288	—	3830
March	I	..	530	248794	9300	42	9342	2558136	4955	—	4000
	II	..	530	248453	9300	20	9320	257773	5284	—	4250
April	I	..	530	247508	9300	16	9316	256824	4950	—	4000
	II	..	530	247053	9300	17	9317	256100	3894	—	4000
May	I	..	530	247378	9300	15	9315	256423	3458	—	4250
	II	..	530	247611	9300	4	9304	256715	1350	1364	4000
June	I	..	531	249102	9300	10	9310	258412	1223	1862	4000
	II	..	532	250864	9300	3	9803	260667	3690	4549	4000
	TOTAL	..			537230	27451	564771		159773	222274	167743

APPENDIX IV-A (*concld.*)

Month & Period		Draw off (*contd.*)			Total draw off	Storage at the end of fort-night	Reser-voir El.at the end of the fort-night	Average Reser-voir level	Tail water level below N.S. Dam	Head available		Power output	
		Power Draft	Evaporation							Gross	Net	at 100% L.F.	at 60% L.F.
		Cusecs.	In-ches	M.cft.	M.cft.	M.cft.	ft.	ft.	ft.	ft.	ft.	K.W.	K.W
	(1)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(41)	(22)
July	I ..	12165	3	528	48491	249019	513	530·5	240	290·5	288·5	255596	390000
	II ..	5082	3	531	42385	256686	534	532·5	240	292·5	290·5	98500	164000
Aug.	I ..	10610	3	534	50886	256033	534	534·0	240	294·0	292·0	206000	344000
	II ..	4676	3	579	45520	302015	554	544·0	240	304·0	302·0	94000	156500
Sept.	I ..	7430	3	605	42701	329526	566	560·0	240	320·0	318·0	158000	262000
	II ..	8500	3	585	43924	326645	564	565·0	240	325·0	323·0	184000	306000
Oct.	I ..	10000	3	582	41740	314832	559	561·5	240	321·5	319·5	219000	350000
	II ..	7656	3	573	40011	302270	554	556·5	240	316·5	314·5	160300	267000
Nov	I ..	8380	2	385	37357	276046	544	549·0	240	309·0	307·0	171000	286000

	II	..	7056	2	382	31019	255408	533	538·5	240	298·5	296·5	140000	233000
Dec.	I	..	3080	2	372	13813	251944	532	532·5	240	292·5	290·5	60000	100000
	II	..	3065	2	366	11582	249945	531	531·5	240	291·5	289·5	59000	98500
Jan.	I	..	3080	2	386	8816	250622	532	531·5	240	291·5	289·5	59500	99000
	II	..	3065	2	368	11143	248882	530	531·0	240	291·0	289·5	59000	98500
Feb.	I	..	3163	2	364	10315	247432	530	530·0	240	290·0	288·0	67000	101000
	II	..	3163	2	364	8482	248794	530	530·0	240	290·0	288·0	61000	101000
March	I	..	3080	4½	728	9683	248453	530	530·0	240	290·0	288·0	59400	98000
	II	..	3065	4½	731	10265	247508	530	530·0	280	290·0	288·0	58500	97500
April	I	..	3080	6	1091	10041	247053	530	530·0	200	290·0	288·0	59000	98500
	II	..	3080	6	1091	8992	247378	530	530·0	240	290·0	288·0	59400	98000
May	I	..	3065	6	1104	8812	247611	530	530·0	240	290·0	288·0	59400	98000
	II	..	3080	6	1000	7813	249103	531	530·5	240	290·5	288·5	59500	98500
June	I	..	3080	4½	735	7818	250864	532	531·5	240	291·5	289·5	59600	98500
	II	..	3980	4½	728	12987	247700	530	530·0	240	291·0	289·0	59500	98500
TOTAL		..			114786	564576								

APPENDIX V-A

Note on Spillway Capacity forwarded to the Administrator, Nagarjunasagar Project.

Copy of the D.O. Letter No. COPP/I&P/MP/NS-32 dated the 7th January, 1959 from Shri M.P. Mathrani, Member, Irrigation & Power Team to Shri S. Chakravarti, Administrator, Nagarjunasagar Control Board.

"I am enclosing herewith a note (3 copies) on maximum flood discharge and spillway capacity for Nagarjunasagar Dam prepared by our Team.

2. It will be seen from this note that there are many discrepancies in the basic data of the discharges of Vijayawada Anicut. The whole design is based on the discharges of this Anicut. It would, therefore, be desirable to have a correct statement of discharges of Vijayawada Anicut for the period from 1894 to 1958. It will be interesting to know as to what are the reasons for such discrepancies in discharges given in different project reports.

3. The next step will be to prepare the probability curve on the basis of correct discharges.

4. As this is a very important item in the design of the Dam, it would be desirable to base the design on indisputable data.

5. It has been suggested in the note that the free board should not be encroached upon at this stage when the Dam construction work has been started.

6. It will also be desirable to allow for a small flood lift between the F.R.L. and M.F.L.

7. Views of your technical officers may kindly be obtained on this note and communicated when an opportunity will be taken to discuss the matter personally on our next visit."

Note on maximum flood discharge and Spillway Capacity for Nagarjunasagar Dam by Irrigation and Power Team

The data for ascertaining the maximum flood discharge of the river Krishna at Nagarjunasagar dam site has been obtained from the following project reports which have been made available by the Project Authorities :—

1. Krishna-Pennar Project Volume I (1951-Scheme)
2. Report on the Lower Krishna Project (Nandikonda site) 1952.
3. Joint Report on Nandikonda Project by Andhra and Hyderabad States—1954.

APPENDIX V-A (*contd.*)

2. For consideration of the maximum flood discharge of river Krishna at Nandikonda site reference has been made to the flood discharges of this river at Vijayawada anicut, which is about 110 miles down stream of the dam site. It is mentioned in the joint 1954 report that the records of the flood discharges of the river at Vijayawada anicut are available for 51 years. From the hydrographs available in the same report, it appears that the records of the high flood discharges are available from the year 1894 onwards. The record should thus be available for the period of 65 years upto 1958. The record of the high flood discharges from the year 1894 onwards has not been tabulated in any of the reports. A table has been prepared of the high flood discharges from 1894 to 1949 from the hydrographs available, which is attached.

3. A table of peak flows in Krishna at Vijayawada anicut has been given in Krishna-Pennar Project Report (1951) for the years from 1925 to 1944. These are also shown in the above table. From this it will be seen that there are considerable discrepancies in the maximum flood discharges in some years. These discrepancies need to be reconciled to arrive at correct probability curve.

4. In he Krishna-Pennar Project Report, it has been mentioned that a flood of the greatest magnitude that has occurred in living memory at the Siddheswaram site occurred in September 1949. This was estimated at 9,50,000 cusecs against 10,52,821 cusecs at Vijayawada. The highest flood discharge in the hydrographs of 1954 report is shown as 9,21,600 cusecs. This is rather a serious discrepancy as the hydrograph discharge at Vijayawada is lower than that at Siddheswaram.

5. The catchment of the river at Siddheswaram is shown as 78,774 sq. miles, at Nandikonda site 83,087 sq. miles and at Vijayawada 97,050 sq. miles.

6. The highest flood discharge recorded at Vijayawada as shown in 1954 report is 10,60,880 cusecs on 7th October, 1903 while in 1951 report it is shown as 11,93,901 cusecs for the same date. In the printed Souvenir on Krishna Barrage at Vijayawada, the maximum discharge is shown as 11.9 lakh cusecs on the 7th October, 1903. Thus there is serious discrepancy in the maximum discharge in two reports. This will affect the probability curve very much. In an important structure of this kind, it is essential that a proper thorough study should be made of the data of peak flood discharges available.

7. For determining the maximum flood discharge at Nandikonda site, a probability curve has been plotted from the data of the yearly maximum discharges at Vijayawada and it is mentioned in 1954 report that the curve shows that the highest flood discharge of 10,60,880 cusecs can be expected once in 80 years. In the Krishna-Pennar Project Report, it is mentioned that the probability studies on the basis of the observed maximum annual flood discharges show as follows :—

1000-year flood	15,87,000
100-year flood	11,96,000
20-year flood	9,12,000

APPENDIX V-A (*contd.*)

The 1952 report shows a flood discharge of 12,57,606 cusecs which has a probability of 150 years.

8. The high flood discharge of the river at Nandikonda site has also been worked out from the formula of late Nawab Ali Nawaz Jung Bahadur and it is shown as 10,88,500 cusecs for a catchment of 80,000 sq. miles, which according to the probability curve will be of frequency of 82 years.

9. For the Siddheswaram site maximum flood level discharge of one million cusecs has been assumed which gives the value of C equal to 545 in C.M.

10. In the design for the Krishna-Pennar Project the spillway capacity provided consists of 25 crest gates of 60′ span 28′height and 28 Nos. river sluices of 10′ x 20′ each. The flood discharge through the spillway gates is 8 lakh cusecs and through the river sluices 2.4 lakh cusecs. The total surplussing capacity under M.W.L. condition is thus 1.04 million cusecs. With the open height of 3′ above M.W.L. a total discharge of 1.2 million cusecs can be passed in an emergency. The full reservoir level provided in that project is 2′ below the maximum water level. The Lower Krishna Project 1952 for Nandikonda site provides 27 flood gates 60′ x 30′ each. The discharge through the flood gates is shown as 10,27,350 cusecs. 12 river sluices of 10′ x 20′ each are provided. These sluices are capable of discharging 2,30,266 cusecs at F.R.L. The surplussing capacity provided therefore is 12,57,606 cusecs which has a probability of 150 years. In the joint report of 1954 the surplussing capacity consists of 27 crest gates of 60′ span and 30′ height and 9 river sluices of 5′ x 9′ each. The discharge over spillway is 10,88,500 cusecs and through the sluices 20,000 cusecs. Thus a total surplussing capacity of 10,47,350 cusecs has been provided.

11. The execution of the project has been undertaken on the basis of the 1954 Project. It appears that the design of the spillway is proposed to be modified. The surplussing capacity will consist of 24 bays of 50′ clear width x 40′ high and 12 sluices of 5′ x 9′. The discharging capacity of the spillway works out to 11,45,000 cusecs and the discharging capacity of 12 sluices is 42,468 cusecs. The total discharging capacity of the spillway and sluices together works out to 11,87,468 cusecs. This is considered to be more than enough for the 100 years flood. The maximum probable flood of 1000 years frequency is now estimated to be 13,83,000 cusecs against 15,87,000 cusecs calculated in Krishna-Pennar Project at Siddheswaram site which is about 50 miles upstream of Nandikonda site.

12. It will thus be seen that there are not only discrepancies in the peak flood discharges at Vijayawada but there are discrepancies in the various flood discharges of frequency for 100, 150 and 1000 years.

13. It may be mentioned that the peak flood discharges both for Siddheswaram and Nandikonda site are based on the flood discharges observed at Vijayawada. The catchment of Krishna river below Nandikonda is tapering but the river section keeps on increasing. Thus the

river below Nandikonda site will have greater and greater flood absorbing capacity lower down. In none of the project reports the question of flood absorption capacity of the river has been considered. It is not unusual to have higher peak discharges in the rivers, which have got very large catchments, which are tapering towards the sea, in higher reaches than those in the lower regions near the sea. No comparative data is available showing the peak discharges at Vijayawada and higher up at any of these sites excepting for the Siddheswaram site for the year 1949. The corresponding discharge shown at Vijayawada in Krishna-Pennar Project Report is different from that shown in the hydrographs in the joint report of 1954. In this connection it may be mentioned that the highest flood discharge of river Indus below Panjnad was higher than that at Sukkur which is about 150 miles below Panjnad junction and the high flood discharge at Sukkur was very much higher than that at Kotri about 200 miles lower down. This was due to the large flood absorbing capacity of the river Indus below Panjnad.

14. It is mentioned in various reports that after the construction of the Nandikonda dam and upper dams like Tungabhadra and Koyna the intensity of the floods will be moderated to a great extent. It is to be considered whether this assumption is correct or on the contrary the high flood intensity may increase, if the upper reservoirs are not provided with any flood absorption capacity. It may be mentioned that in case of Koyna it has been worked out that the peak rate of flood flow in the unrestricted channel, which would be 2,77,738 cusecs, would increase to 4,94,000 cusecs in the dam on account of the reduction of the flood absorption capacity of the river above the dam. It may happen that the highest flood discharge may come when the upper reservoirs and the reservoir at Nandikonda site are full. Under those conditions there will be considerable reduction in the flood absorption capacity of the rivers above the dams which would increase the peak flood intensity considerably at Nandikonda site. It is unfortunate that no river sections are given above the Nandikonda site and no calculations have been done for the reduction in the flood absorption capacity of the river above the dam.

15. It would therefore not be safe to rely on the flood absorption capacity of the upper reservoirs unless there is specific provision for the same and they are not too far above the storage site under consideration.

16. In the present design the full reservoir level and the maximum reservoir level are kept the same. Thus there is no flood absorption capacity in the reservoir at all. As a matter of fact this may cause trouble sometimes. It may happen that the regulating staff at the dam may not be able to raise the gates fast enough in case the highest flood is coming, when the lake is full, fearing that the valuable storage may be lost. The regulation of the gates may take some time. In the C.W. & P.C. Memorandum on spillway it has been mentioned that the flood moderating capacity of the reservoir in the 4′ rise above F.R.L. is 0.15 M.C. Ft. This is hardly 2 hours discharge of a flood of the magnitude of 12 lakh cusecs. It would seem to be desirable that maximum water level of a reservoir of this magnitude should be a few

feet above the full reservoir level for design purposes to allow time for regulation in an emergency. In case of Siddheswaram reservoir the maximum water level has been kept 2′ above the F.R.L.

17. The assessment of design flood is rather a difficult problem and all the available data and facts have to be sifted and assessed carefully. In this connection the following extracts from "Engineering for Dams" by Creager, Justin and Hinds (1947) would of interest.

"Recently, however, it has been proved by advance studies and a greater accumulation of data, that the probability method is entirely inadequate".

"Thus floods have occurred on rivers which, based on probability studies of prior records of considerable length, would have a frequency not of the usually adopted 1,000 to 10,000 years but a frequency of once in millions and even billions of years".

"Hazen recognised this peculiarity of floods but because of lack of verifying data, he disregarded this possibility in his analysis of floods and behind that it should be considered an indication of the necessity of using the most conservative methods. But since that time the phenomenon has been reported so often to change the possibility to practically a certainty".

And finally "In making use of records of maximum recorded floods on river in a given district to estimate the expected peak discharge at a given place, it must be remembered that what has occurred in the past must surely be exceeded in the future."

These extracts have been taken from Koyna Hydro-electric Project Report of 1952.

18. In view of all these factors it is for consideration whether the high flood discharge for the Nagarjunasagar Dam should not be fixed at least at 15,87,000 cusecs as worked out in Krishna-Pennar Project for 100 years flood. While working out the spillway capacity it would not be desirable to encroach upon the free board provided in the design. There should also be a small difference say of 3′ to 4′ between the F.R.L. and M.F.L. to allow for regulation being done safely in an emergency, if high flood discharge comes rapidly.

19. It may be mentioned that the flood discharge in this river can rise very rapidly as is indicated by the catastrophe that occurred at Vijayawada anicut on 24th May, 1952. "There was a sudden flood of unprecedented magnitude and the water level rose so rapidly that it had not been possible to remove the locking pins and consequently they could not be tripped by hydraulic pressure". "The water level at the anicut stood at 1′ below the crest, on the 24th morning and rose to 0.6′ below the crest by 12.00 noon. The water rose rapidly after 3.00 P.M. At 4.00 P.M. it was 4′ above the crest. Subsequent levels were 6′ at 5.00 P.M., 8′ at 6.00 P.M. and 12′ over the anicut by 7.00 P.M. Though the rate of rise diminished afterwards, the river continued to rise at 1′ per hour until it was 14′ at 9.00 P.M. and 14.7′ at midnight and reached the maximum height of 16′ over

the crest that is 9' over the shutters at 5.00 A.M. on 25th May, 1952"

20. If the F.R.L. and M.F.L. are designed to be the same, there is a danger of the M.F.L. being exceeded in an emergency of the kind that occurred in May 1952.

21. There has been a recent catastrophe on Kadam dam in this State. The dam was over-topped on account of an unprecedented flood. No details of this catastrophe are available to the Team.

22. The risk in the over-topping of a dam like Nagarjunasagar is so considerable that all possible precautions should be taken in the design of the surplussing capacity.

23. In view of all these factors it would not be safe to design for the high flood discharge of 100 years' frequency as is proposed at present. Even if the Dam is designed for the high flood discharge of 1000 years frequency as worked out in Krishna-Pennar Project, it would not be safe to encroach on the free board. That should be reserved to take care of any unprcedented and unexpected flood.

TABLE NO. 1

Comparative peak flows in Krishna at Vijayawada Anicut as shown in Hydrographs in Joint Project Report (1954) and in Krishna-Pennar Project of 1951.

Sl. No.	Year	Peak flow in cusecs from Hydrographs.	Peak flow from Krihna-Pennar Project 1951.	Remarks
(1)	(2)	(3)	(4)	(5)
1.	1894	577,745		
2.	1895	496,137		
3.	1896	760,425		
4.	1897	619,067		
5.	1898	624,082		
6.	1899	404,606		
7.	1900	718,538		
8.	1901	513,433		
9.	1902	547,636		
10.	1903	1,060,830	11,94,000	Page 2 of Krishna-Pennar Project.
11.	1904	479,442		
12.	1905	483,119		
13.	1906	462,884		
14.	1907	495,374		
15.	1908	571,648		

APPENDIX V-A (*contd.*)

(1)	(2)	(3)	(4)	(5)
16.	1909	653·450		
17.	1910	369,783		
18.	1911	319,736		
19.	1912	543,474/84,043		
20.	1913	417,815/487,712		
21.	1914	948,632/961,990		
22.	1915	578,242/573,934		
23.	1916	955,460/955,460		
24.	1917	498,071/498,071		
25.	1918	253,797/253,800		
26.	1919	455,780/456,000		
27.	1920	392,022/381,000		
28.	1921	558,313/565,000		
29.	1922	498,866/512,715		
30.	1923	624,116/622,637		
31.	1924	634,352/634,816		
32.	1925	613,249/613,692	6,03,978	Page 2-3 of Kistna-Pennar Project.
33.	1926	552,338/552,361	7,49,615	
34.	1927	560,278/560,621	5,60,278	
35.	1928	461,344/491,432	9,78,730	
36.	1929	458,177/486,437	3,46,151	
37.	1930	369,878/370,807	3,69,978	
38.	1931	468,072/452,562	4,68,072	
39.	1932	511,936/525,080	5,11,956	
40.	1933	632,139/631,219	5,32,139	
41.	1934	384,012/389,504	6,32,139	
42.	1935	360,194/373,683	3,84,012	
43.	1936	350,003/351,441	—	
44.	1937	392,624/395,770	3,50,003	
45.	1938	370,464/378,200	3,92,624	

APPENDIX V-A (*concld.*)

(1)	(2)	(3)	(4)	(5)
46.	1939	441,511/408,797	3,70,474	
47.	1940	353,617/360,255	4,01,511	
48.	1941	381,703/394,378	3,53,617	
49.	1942	380,980/392,187	3,81,703	
50.	1943	426,821	3,80,980	
51.	1944	385,334/393,062	4,26,205	
52.	1945	374,641		
53.	1946	475,328		
54.	1947	443,374		
55.	1948			
56.	1949	921,606		

Notes : Discharges pertain to Vijayawada Anicut 110 miles below damsite. Total catchment area at Vijayawada anicut 97050 sq. miles. Catchment area between Vijayawada anicut and damsite 13,963 sq. miles. Discharges computed from gauge readings of Vijayawada Anicut site. Applying the formula for broad crested weir in the peak discharge figures given on the drawing, numerator indicates average peak discharge for the day and denominator momentory peak dishcharge.

Due to clear overfall conditions of flow at Vijayawada Anicut formulae different from those now employed have to be adopted for computing discharges, and it is therefore likely that actual discharges will be greater than those shown in the hydrographs.

APPENDIX V-B

Second note on Spillway Capacity forwarded to Administrator, Nagarjunasagar Project.

Copy of the D.O. Letter No. COPP/I&P/MP/NS-64 dated the 6th March, 1959 from Shri M.P. Mathrani, Member, Irrigation & Power Team to Shri S. Chakravarti, Administrator, Nagarjunasagar Control Board.

"I am enclosing herewith a further note on maximum flood discharge and spillway capacity for Nagarjunasagar Dam.

2. It is requested that very early comments may kindly be offered by the Project authorities on this matter as it is of great importance that this question must be settled as early as possible."

Second note on maximum flood discharge and spillway capacity for Nagarjunasagar Dam by Irrigation and Power Team.

In the previous note that was prepared certain discrepancies in the high flood discharges at Vijayawada were visible. On inquiry from the Nagarjunasagar Project Authorities it has been ascertained that at the time of preparation of the Krishna-Pennar Project certain model experiments were made at Guindy Research Station for determination of the co-efficient of discharge for the Vijayawada Anicut. A copy of the note on the model experiments carried out is enclosed. It would be seen that the co-efficient of discharge given by the model experiments was much higher than that adopted in working out Vijayawada Anicut discharges. It appears that the fresh discharges were worked out from the formula obtained by model experiments on the basis of which high flood discharges were worked out for different flood frequencies as mentioned in the previous note. It is understood that this formula has not been adopted by the Andhra State. On the basis of the old formula we get lower run off of Krishna river at Vijayawada Anicut. This is probably on the safe side so far as the annual run-off is concerned. It would, however, be more realistic and safe to adopt discharges as given by the formula based on model experiments for the purpose of spillway capacity of the Dam.

It may be mentioned that while designing the spillway capacity both in case of the Krishna-Pennar Project and 1954 joint report on Nandikonda by Andhra and Hyderabad States the co-efficient of discharge was taken as 3.75 and end contractions as

$$I_n = I_t - 0.04\ nh_c$$

In the present design the co-efficient of discharge is proposed as 3.98 and end contractions as

$$I_n = I_t - 0{\cdot}03\ nh_c$$

It is for consideration as to what co-efficient of discharge should be adopted and what end contractions should be allowed while providing the capacity of the spillway.

APPENDIX V-C

Note on Model experiments for deciding co-efficient of discharge of Vijayawada Anicut, received from C.E. Nagarjunasagar Dam.

Copy of letter No. 604/T/4 dated the 2nd March, 1959 from the Chief Engineer, Nagarjunasagar Dam, (Technical Wing) to Irrigation & Power Team.

"Sub : Extract of Appendix 9-1 Note on Determination of co-efficient of Discharge—from K.P.P. Report Vol. : III Appendices—1951.

Ref. : Telegram Dt. 24-2-59 from Plan Projects.

With reference to the above telegram, a copy of the note on determination of coefficient of discharge of Krishna Anicut at Vijayawada, extracted from K.P.P. Reports Vol. : III (Appendices 1951) is herewith enclosed."

APPENDIX 9.1

KRISHNA ANICUT AT VIJAYAWADA

DETERMINATION OF COEFFICIENT OF DISCHARGE

1. *Introduction* :

1.1. The flood estimates of the Krishna River were principally based on the gauge observations at the site of the Anicut across the river at Vijayawada. In connection with the investigation for the Krishna Pennar Project it was found desirable to verify by model experiments if the procedures formerly adopted for estimating the flood discharges were reliable.

1.2. A cross-section of the weir is shown in Fig. 1. In computing the discharge over the anicut in the past, the standard formula for submerged weirs given in the M.D.S.S. (Madras Detailed Standard Specifications) Vide 1946—Page 309—Appendix XIV were being employed.

1.3. Acording to this formulae the discharge for a drowned weir is computed by the formula.

$$q = 3{\cdot}1 \left\{ (h+h_a)^{3/2} - h_a^{3/2} \right\} \times (h+h_a)^{3/2} + 8 \text{ c.d.} \quad (1)$$

where q = discharge per foot width of anicut in cusecs.

h = known difference of water level between the front and the rear, or the 'Afflux' in feet.

h_a = Head due to velocity of approach in feet $= \frac{Va^2}{2g}$

APPENDIX V-C (*contd.*)

where Va = Velocity of appraoch in feet/sec.
c = coefficient of discharge as per table below
d = depth of tail-water over crest in feet.

Table of Values of c

Depths of tail-water	
1 to 5 feet	0·60
6 feet	0·62
7 feet	0·66
8 feet	0·75
9 feet	0·84
10 feet	0·90
11 feet	0·93
12 feet and over	0·95

1.4. The criterion for submersion of the weir is that the tail-water level should be at or above the crest of the anicut.

1.5. For the conditions of flow when the tail-water level is below the crest the anicut discharges in the free-overfall condition. The formula for the free-overfall condition can be deduced from the formula (1) above for the drowned condition by substituting d = depth of tail-water above crest O.

$$q = 3 \cdot 1 \left\{ (h + h_a)^{3/2} - h_a^{3/2} \right\} \quad .. \quad (2)$$

In this equation:

h = head in feet or the depth of flow over the crest and not the difference between upstream and downstream water elevations as in equation(1).

1.6. The Chief Engineer for Irrigation wanted that the Precise Calbiration curve for the weir might be furnished by model experiments and expressed the opinion that the discharges of the Anicut was perhaps being underestimated in the past. The results of model experiments conducted for the purpose are described below :

2. *Description of Experiments* :

2.1. A section model to scale 1/48 was constructed in masonry and fitted in a masonry flume 3 feet wide. The crest level of the anicut being + 47.05, the upstream bed level was maintained at + 37.05 which was the average level as seen from the river charts. Similarly the downstream bed level was maintained uniform at + 27.24 which represented the average bed level as disclosed by the contour plan of the river bed. The upstream approach, the anicut and the downstream reach of the flume were all rendered rigid in cement mortar plastered smooth. The upstream and downstream water level elevations were measured in gauge-wells by the aid of pointer gauges. Pointer gauges were also used for tracing the surface profile of water under different conditions of flow.

APPENDIX V-C (*contd.*)

2.2. In some of the previous studies the discharge measurements were being made quantitatively in a volumetric tank. However, this method was not sufficiently precise since no arrangements were provided for diversion of water and consequently the water surface had to be measured not under still conditions but in its course of rising. To obviate the errors thereby introduced in the determination of discharge, in the present series of experiments recourse was had to be use in Rehbock's universal weir formula given below :

$$Q=\frac{2}{3}\left\{0{\cdot}65+\frac{1}{320\,h_o-3}+\frac{6{\cdot}08\,h_o}{p}\right\}\times\sqrt{2g}\,bh_o^{3/2}$$

(vide page 119, Hydraulic Laboratory practice by Freeman).

where Q=discharge in cusecs,

h_o=head in feet.

b=length in feet.

p=height of weir in feet.

The exactness of this formula has been attested by several experimenters after verification in their own laboratories as reported in the Hydraulic Laboratory practice by Freeman. (Am. Soc. Mech. Engineers) 1929.

2.3. In conducting the studies, use was made of the graph shown in Fig. 2 connecting upstream and downstream gauge readings plotted from data of prototype gauge register. The experiments were conducted for a range of about 6 feet to 25 feet depths of overflow on the crest, being the height of the crest shutters and about 21.5 feet being the observed M.F.L. depth over the crest. In conducting the experiments, suitable discharge was admitted to the model so as to attain the desired upstream depth of flow. Under steady conditions, observations were made on the gauging weir for computing the precise model discharge employing Rehbock's formula. For any particular discharge admitted to the model, observations were made for the following three different conditions of operation of tail-gate *viz.* : (*a*) with tail gate off, (*b*) with tail gate raised so as to build up the tail-water level corresponding to that of the upstream depth as per prototype observations, and (*c*) with the tail gate raised so that the upstream water depth just got affected and the modularity ceased. In all the conditions the surface profiles were traced. These are illustrated in Figs. 3(*a*) to 3(*e*). With the experimental data collected, the following computations were made and the conclusions drawn.

3. *Discussion of Results* :

3.1. In Fig. 2 which shows the graph connecting the upstream and downstream gauge readings as observed in the prototype, a second graph connecting the upstream and the corresponding downstream water elevations, for which modularity just ceased as obtained by model observations is also plotted in the same Figure. The observations are also furnished in the form of a statement in Table I. It will be clear from this fig. that for a particular upstream water level,

APPENDIX V-C (*contd.*)

the tail water level at which modularity ceased is always higher than the actual tail-water level as obtained in the prototype. In other-words, for the complete range of operation of the weir extending from about 6 feet to 25 feet, free overall condition of the weir existed. Hence the equation for computing the discharge for all depths of overflow in the prototype takes the form.

$$Q = C_d\, L \left\{ (H + h_a)^{3/2} - (h_a)^{3/2} \right\} \quad \ldots \quad (1)$$

Where Q = discharge in cusecs.

C_d = coefficient of discharge.

L = Length of the weir in feet.

H = Head over the crest in feet or the difference between the upstream water level and the crest level.

h_a = head due to velocity of approach.

$$= \frac{V_a^2}{2g}$$

Where V_a = Velocity of approach in feet/sec.

3.2. Employing the equation above, and computing the model discharge using Rehbock's formula the value of C_d for each depth of overflow was evaluated. Fig. 4 shows the graph connecting C_d and head over the crest. The value of C_d increases steadily with the head through at a diminshing rate the range of variation being 2.99 for a depth of over-flow of about 7 feet to 3.15 for the M.F.L. conditions.

3.3. In reference to the Fig. 4 and the equation employed for computing the coefficient of discharge it is important to observe that the use of the discharge equation with velocity of approach term included in it has not resulted in a constant value for C_d. It is therefore, considered that an adoption of a simpler type of equation of the form, $Q = K.\ L.\ H.^{3/2}$ (2). (where K is the coefficient of discharge which allows for velocity of approach and H is the head over the crest), would greatly result in case of computation without sacrificing accuracy. The values of K to be used in the above equation are also plotted in Fig. 4 from which it will be seen that K increases from 3.15 for a head of 7.5 feet to 3.6 for a head of 25.5. The use of the simpler form of the equation and the graph for K is recommended for adoption in the field.

3.4. From a perusal of water surface profiles furnished in Figs. 3(*a*) to 3(*e*) it will be clear that clear overfall conditions which exist for all conditions of over-flow in the prototype are caused owing to the formation of the standing wave *vide* photograph No. 2. The surface profile observed during the recent floods and the remarks of the field officers are furnished in Fig. 5. In this instance the verification of the formation of the standing wave is corroborated by model and prototype observations, though the form of the-jump profiles in the two

APPENDIX V-C (*contd.*)

cases, are not similar. But in as much as the prototype observations could only represent the phenomenon on one flank of the anicut, whereas the model observations pertained to conditions obtaining in the Central section, the slight dissimilarity in the form of the hydraulic jump might not be of much significance.

3.5. Making use of the value of K as obtained in Fig. 4 computations on discharges for different depths of over-flow on the crest are made as per the free discharge formula (2) as well as by the usual formula for discharge over anicuts furnished in M.D.S.S. 1946 *vide* page 309 and the results are presented in tabular statement No. 2. According to formula given in M.D.S.S. for the conditions of flow when the tail-water elevation rises above the crest level the anicut is treated as submerged and the discharge is computed on the assumption that the submerged portion acts as an orific and that the section above acts as a free overfall weir. As already remarked in the beginning the model studies have disclosed this assumption to be untenable for the Krishna Anicut, in view of the fact that despite the tail-water level being above that of the crest level the modularity gets unaffected for all depths of overflow on the crest. Hence the use of the submerged notch formula leads to errors in the measurements of discharge. In table 2 the difference in the discharges by both the formulae are expressed as percentages of the actual discharge computed by the free discharge formula. From the data furnished in the table 2, curves connecting the head over crest and the percentages difference in discharges as computed by both the formulae and secondly head over crest versus afflux were plotted in Fig. 6. It will be clear from this Fig. that the two curves attain their critical values at the same head of over-flow on the crest viz. 17.7 feet in Fig. 7 the variation in percentage error in discharge with the afflux is also illustrated.

3.6. Further analysis of the experimental data was made to discover the functional relationship connecting the downstream depth of flow in the river and the discharge, though this study was not essential for the programme of investigations on coefficient of discharge characteristics. Figure 7 shows the logarithmic plotting of discharge versus the downstream depth of flow above the river bed "h" from which the following equations are deduced :

$Q = 1{\cdot}625\ h^{3/2}$

(This holds good for values of depth of flow over the crest "H" upto 18 feet).

And $Q = 1{\cdot}285\ h^2 - 125$ (This holds good for depths of flow over the crest 'H' greater than 18 feet.)

3.7. In conducting a study of the coefficient of discharge on a broad crested weir, special attention should be paid to the simulation of friction to scale in the model. While the flow over a weir is governed by Froudian law which implies geometrical similarity friction plays the minor role of introducing errors due to scale effects. According to friction scale deduced from Manning's equation and applicable to open channel flow the rugosity coefficient in the model should be in 1/6 times the rugosity coefficient in the prototype, where "n" is the scale

APPENDIX V-C (*contd.*)

of the model. Thus assuming a value of 0.017" for the rugosity coefficient in the prototype (for rubble masonry), the value of rugosity coefficient in the model should be

$$0{\cdot}017/n^{\frac{1}{6}} = 0{\cdot}017/48^{\frac{1}{6}} = 0.01 \text{ nearly.}$$

This value approximates to that in the model whose surface was plastered smooth in neat cement mortar. Hence, the values of the coefficient of discharge deduced on this model could be directly applied to the prototype.

3.8. In conclusion, it should be remembered that the discharge over the Krishna Anicut could be reliably computed making use of the discharge equation of the form $Q = K. L. H.^{3/2}$. The values of K are given in the form of a graph and tabular statement in Figure 4. In making use of Figure 4 for reading values of K, it might be noted that the value of 'H' might need a correction if the upstream guage is located in the region of draw-down effect in the prototype since the values of 'H' furnished in Figure 4 were obtained from model experiments in which the upstream gauge was located beyond the draw-down effect.

4. *Conclusion* :

(*i*) The Krishna Anicut functions in the free discharge condition for all depths of overflow obtained in the prototype notwithstanding the fact that for certain stages of flow the tail-water elevation is higher than the crest level.

(*ii*) The discharge could be computed accurately making use of the equation $Q = K. L. H.^{3/2}$ and the graph furnished in Figure 4 connecting K and H for depths of overflow from 6 feet to 25 feet.

(*iii*) For a depth of overflow less than 6 feet the usual formula as per M.D.S.S. may be followed.

(*iv*) The percentage error committed by using the standard submerged weir formula increases with increase in head upto about 18 feet and it decreases with increase in head for higher values.

The following were the personnel in charge of the experiments above during the periods noted against their names :

1. Executive Engineer :	Shri J.I. Coil Pillai, E.E., August, 1949 —December, 1949.
2. Assistant Research Officer :	Shri J. Visweswara Rao, B.E., M.S.c., A.M.I. Struct. E(Lon) Assoc., M.A.S.C.E., August, 49 — December, 1949.
3. Supervisors :	Shri A. Lakshmanaswamy, B.E., November, 1949 — December, 1949.
	Shri K. R. Aravamuthan, B.Sc., B.E., from August 1949 to December, 1949.

APPENDIX V-C (*contd.*)

TABLE I

A—2 (IV)

TABULAR STATEMENT

No.	Upstream water level	Head over crest in anicut in ft.	Downstream water level			Value of K
			Tail gates off.	Prototype D.W.L.	Modular Limit	
1	+54·05	7·00	+27·90	+49·00	+53·15	3·09
2	+56·85	9·80	+29·20	+54·10	+55·90	3·26
3	+60·12	13·07	+30·65	+58·62	+59·75	3·51
4	+62·62	15·57	+31·90	+61·37	+61·45	3·50
5	+64·75	17·70	+33·10	+63·35	+63·92	3·54
6	+66·45	19·40	+33·96	+64·75	+65·22	3·57
7	+68·45	21·40	+35·00	+66·30	+67·39	3·60
8	+69·55	22·50	+35·80	+67·00	+68·10	3·60
9	+70·80	23·75	+36·45	+67·80	+69·45	3·60
10	+72·43	25·35	+37·34	+68·60	+69·85	3·60

APPENDIX V—C (*concld*)

TABLE 2

A—2 (IV)—1

Heads over crest in feet	Prototype reduced levels		Afflux in feet	Discharge as per Research Station formula per foot run in cusecs	Discharge as per M.D.S.S formula per foot run in cusecs	Difference expressed as percentage of correct discharge
	Up-stream level	Down stream level				
1	2	3	4	5	6	7
8	+55·05	+51·05	4·00	71·45	66·89	6·393
10	+57·05	+54·25	2·80	101·88	84·06	17·520
12	+59·05	+57·15	1·90	137·35	123·36	10·020
14	+61·05	+59·65	1·40	175·57	139·41	20·590
16	+63·05	+61·65	1·40	217·00	159·65	26·860
18	+65·05	+63·65	1·40	261·14	185·79	28·860
20	+67·05	+65·15	1·90	309·63	240·22	22·420
21	+68·05	+65·90	2·15	344·29	268·15	22·120
23	+70·05	+67·25	2·80	385·35	333·66	13·420
25	+72·05	+68·45	3·60	438·95	407·75	7·063

Formula used in the Research Station.

$$q = KH^{3/2}$$

Where K = Coefficient of discharge.

H = Head over the anicut.

M.D.S.S. Formula :—

$$q = 3.1\left\{(h - h_a)^{3/2} - h_a^{3/2}\right\} - 8\ C_d\ (h - h_a)^{\frac{1}{2}}$$

Where h = difference of water level between front and rear.

h_a = head due to velocity of approach.

APPENDIX V-D

Final Note by Irrigation & Power Team on Spillway Capacity for Nagarjunasagar sent to C.W. & P.C.

Spillway Design :

The spillway capacity is one of the most important items in the design of any dam. Any defect in the design of the spillway can prove catastrophic. The 1954 Project Report refers to the question very briefly. The maximum flood discharge has been based by reference to the discharges of the river Krishna at Vijayawada anicut which is about 110 miles down-stream of Nagarjunasagar Dam. The maximum flood capacity over the spillway through the river sluices has been fixed at 10,47,350 cusecs. The 1956 First Phase Estimate Report makes no further reference to the spillway capacity.

The study of 1951 Krishna-Pennar Project Report, Volume I and Report on Lower Krishna Project of 1952 prepared by Hyderabad State showed that there were some discrepancies in the discharge data at Vijayawada anicut as adopted in various reports. Two notes *vide* Appendix II were prepared and sent to the Project Authorities for their comments. Their comments are given in Appendix III.

The highest flood recorded at Vijayawada anicut occurred on 7th October, 1903. This discharge is shown as 10,60,880 cusecs at page 14 of 1954 Project Report and is shown as 11.94 lakh cusecs at page 4 of the same Report. The Khosla Committee Report also shows this discharge as 11.94 lakh cusecs on 7th October, 1903. In the Krishna Barrage design also this has been taken as the maximum discharge. The discrepancy in the high flood discharges for various years is due to the fact, that at the time of preparation of the Krishna-Pennar Project, certain model experiments were made at Guindy Research Station for determination of the co-efficient of discharge of the Vijayawada anicut. Those experiments showed that the co-efficient assumed in working out the discharge at Vijayawada anicut was on the low side. The Project Authorities have now pointed out that the model used for the experiments did not represent the prototype. One of the main defects pointed out is that the up-stream and down-stream bed levels were taken as constant. It is stated that "it is well known that big islands are being formed continuously during the last several years, ever since the construction of the weir and there has been considerable silting up of the upstream bed. The silting of upstream and the changes in the design in the down-stream project influence the discharge characteristics of the weir considerably even in free flow condition". As a matter of fact the siltation on the up-stream side and the scour on the down-stream side will increase the difference in the two levels, which would still give a higher co-efficient. Other defects have also been pointed out. It has been mentioned that fresh model experiments on three dimensional models are proposed to be made to verify the results

already obtained. This is a very important question. As these discrepancies were known, further experiments if considered necessary should have been made earlier.

There is no data available for the high flood discharges at Nagarjunasagar or Siddheswaram Dam site. Vijayawada anicut is about 110 miles down stream of Nagarjunasagar Dam. It is therefore assumed that the high flood discharge at Nagarjunasagar Dam site is likely to be less than that at Vijayawada. In the note supplied by the Project Authorities, it has been worked out that the value for 1000 year flood on the basis of old discharges will be 14.40 lakh cusecs at Vijayawada and that at Nagarjunasagar Dam site the computed flood will be about 2 lakh cusecs less *i.e.* 12.40 lakh cusecs. In this connection however one very important observation may be made from discharge data of the Indus and Panjnad rivers at various sites. It has been experienced that the high flood discharge is higher in the upper reaches than that in the lower reaches. This can be explained from the fact that the river slopes are steeper in the upper reaches and much flatter in the lower reaches. The river sections in the lower reaches have got a greater flood absorption capacity. Due to these reasons, the peak flood gets flattered in the lower reaches. In this connection copy of an extract from the article entitled, "Floods in the Sutlej, Panjnad and Indus rivers during 1942" in C.B.I. Journal October 1943 is attached. It will be seen that the flood at Islam 200 miles below Ferozepur on river Sutlej was lower than that at Ferozepur during the high floods of 1942.

The Krishna river has got an average fall of about 3.70 feet per mile in a length of 186 miles from Siddheswaram to Pulinchintala. From Pulinchintala to Vijayawada anicut the bed slope is very flat being about one foot per mile or so. It would therefore not be justifiable to assume lower high flood discharge at Nagarjunasagar than at Vijayawada.

The high flood discharge for 1,000 year frequency at Vijayawada anicut flood has been worked out as 15,87,000 cusecs on the basis of new formula in Krishna-Pennar Project Report.

The assessment of design flood is rather a difficult problem and all the available data and facts have to be sifted and assessed carefully. In this connection the following extracts from "Engineering for Dams" by Creager, Justin and Hinds (1947) would be of interest :—

> "Recently, however, it has been proved by advance studies and a greater accumulation of data, that the probability method is entirely inadequate".
>
> "Thus floods have occurred on rivers which, based on probability studies of prior records of considerable length, would have a frequency not of usually adopted 1,000 to 10,000 years but a frequency of once in millions and even billions of years".
>
> "Hazen recognised this peculiarity of floods but because of lack of verifying data, he disregarded this possibility in his analysis of floods except that it should be considered an indication of the necessity of using the most conservative methods.

APPENDIX V-D (*concld.*)

But since that time the phenomenon has been reported so often as to change the possibility to practically a certainty".

And finally "In making use of records of maximum recorded floods on river in a given district to estimate the expected peak discharge at a given place, it must be remembered that what has occurred in the past must surely be exceeded in the future".

In the latest design, the discharging capacity of the spillway and sluices together works out to 11,87,468 cusecs. It has been worked out that a discharge of 13,87,000 cusecs can be passed by encroaching on the free board above full reservoir level by 4 feet without endangering the safety of the dam. Had all these factors been considered in the design stage, it is doubtful if such encroachment would have been made.

The following factors are to be borne in mind, before such a procedure can be adopted :—

(*i*) It is all the while being considered that the high flood discharge at Nagarjunasagar will be some what lower than that at Vijayawada anicut which is 110 miles lower down. The experience on Indus, Panjnad and Jamuna rivers has shown that this is not a justifiable assumption. The flood discharge higher up has been found to be higher than those lower down.

(*ii*) In view of the model experiments for determining the coefficient of discharge having been made, whether it would be safe to ignore results of such model experiment until any further studies have been made.

(*iii*) Whether it would be safe at this stage to encroach on the free board, in view of the risk involved in flood of 1,000 years' frequency being exceeded which as mentioned by various authors, who have dealt with this question, cannot be ruled out.

(*iv*) The spillway portion in the present design is only 1,500 feet out of 4,780 feet of masonry dam. The spillway portion can be increased without much extra cost.

The 1956 First Phase Estimate Report provides a spillway of 1880 feet with 27 gates of 60 feet by 30 feet. This spillway length is now proposed to be reduced to 1,500 feet with 24 gates of 50 ft. by 40 ft. If the number of spillway gates is increased from 24 to 32 the spillway length will be about the same as provided in the first phase estimate. The discharging capacity of the spillway and the sluices will be about 15,69,000 cusecs which is very close to 1,000 years' frequency flood as shown in the Krishna-Pennar Project. Even if this high flood discharge is exceeded an encroachment of 4 feet in the free board which is being contemplated at present, will take care of such an exceptional flood. It will however not be safe to encroach on the free board under the known conditions. The risk involved would be too great.

The extra expenditure involved will mainly be in the cost of the gates. This will perhaps be within Rs. 50 lakhs.

APPENDIX V-E

Comments of C.W. & P.C. on the Irrigation and Power Team's note on Spillway Capacity (dated 3rd September, 1959).

III. *SPILLWAY CAPACITY*

The question whether the flood discharge of the Nagarjunasagar will be lower or higher than Vijayawada Anicut, which is 110 miles lower down, cannot be correctly assessed in the absence of exact information about (i) valley storages between the Nagarjunasagar and Vijayawada (ii) the contribution of the tributaries falling in the Krishna (iii) long term discharge at Nagarjunasagar, and (iv) the correction for the coefficient in the Vijayawada anicut if necessary. The catchment area between the two places is about 14,000 square miles, and is fairly large.

These factors have been examined and it is considered that the peak flood discharge at Nagarjunasagar will not exceed that at Vijayawada. As a result of studies carried out, it is found that a hundred year flood at Vijayawada will be of the order of 12 lakh cusecs and a thousand year flood of the order of 15 lakh cusecs.

Here it may be mentioned that the up-to-date observations do not show any flood higher than 10.6 lakh cusecs which at Vijayawada occurred in 1903.

The existing design of the spillway at Nagarjunasagar Dam is capable of discharging 11.45lakh cusecs at F.R.L. 590. In addition 42,000 cusecs can be escaped through the sluices at the same F.R.L. A total flood discharging capacity of the sluices and the spilway is thus 11.87 lakh cusecs, *which is almost the same as* 100 *year* frequency flood at Vijayawada.

The design of the dam provides a 10′ free board in the masonry section and 15′ free board in the earth section. Without a change in the present design, 15 lakh cusecs flood can be passed with the reservoir rising to about R.L. 594. This would mean encroachment in the above free board on one thousand year flood.

The question is whether this encroachment should be allowed or the design of the spillway changed to ensure that the free board remains as before *viz.*, 10′ in masonry section and 15′ in earth section. For a one thousand year frequency, there would not be much objection to this encroachment on the free board. However, the free board on the masonry section can be regained by adding the height of the dam which will cost much less than the other alternative of adding bays to the spillway. The dam section has been tested for this higher water level and is safe. Free Board in the earth section is ample.

In view of what has been stated above, provision for extra bays need not be made.

APPENDIX V-E (*concld.*)

Extract from copy of para (i) of the Article entitled "Floods in the Sutlej, Panjnad and Indus rivers during 1942", *in C.B.I. Journal, October,* 1943 *by A. Jesson, Superintending Engineer, Bahawalpur State.*

Floods in the Sutlej River

(*a*) Due to abnormal rainfall during August 1942 three major flood occurred in the Sutlej River between August 9th and 31st.

(*b*) The river began to rise at Ferozepur on August 9th and the peak of the first flood was reached on August 14th with a discharge of 3,10,650 cusecs.

On August 15th the discharge fell to 2,85,000 cusecs, but the river started to rise again on August 16th, and the peak of the second flood was reached on August 18th with a discharge of 3,29,725 cusecs.

The discharge fell to 2,60,000 cusecs on August 21st, when the river again started to rise very rapidly, and the peak of the third flood was reached on August 22nd with a discharge of 3,43,350 cusecs.

(*c*) The peak discharge of the three floods, and the maximum discharge for which the Headworks are designed, are tabulated below :—

Name of Headworks	Designed discharge	Peak discharge of		
		1st Flood	2nd Flood	3rd Flood
Ferozepur	4,50,000	3,10,650	3,29,725	3,43,350
Sulemanke	3,25,000	2,82,007	3,01,259	3,31,026
Islam	3,00,000	2,56,000	2,75,000	2,84,100

(*d*) The average time taken by the peak of a flood to travel from Ferozepur to Sulemanke (a distance of 79 miles was 32.5 hours), and from Sulemanke to Islam (a distance of 121 miles) was 67 hours.

APPENDIX V-F

Comments of Central Water and Power Commission on Spillway capacity in their letter No. 1(8) *ADR/MP-3A/59-TE, dated* 13*th October,* 1959.

Item No. III—Spillway Capacity :

(*a*) In the memorandum on spillway it has been stated that in case of a 1,000 years flood of 13,85,000 cusecs even if the duration of the peak intensity is not instantaneous i.e. for a continuous discharge, the water level in the reservoir can rise only to El. 594 or four feet above F.R.L. when the discharge will be 13,85,000 cusecs. The duration of the flood of this intensity can be passed through the spillway for any extended period. When a flood of 15 lakh cusecs had to be sent down, routing procedures have been adopted. For the purpose of routing, a flood hydrograph of an extended base has been assumed and still the maximum level reached was 593.95 or 594. This was done as the known hydrograph for the highest flood of October, 1903 in 62 years caused less rise than a continuous flood of 13.85 lakhs.

(*b*) It may please be noted that the design criteria adopted in our offices is that the spillway is provided on the basis of 100 year flood, free space left for 1,000 year flood and for a 1;000 year flood the structure is tested to be safe. As the maximum W.L. has not altered from 594 to which the dam was originally tested, there is no increase or any alteration in the factor of safety. As it was felt by some, that free board in the first phase should be 10 feet instead of 6 feet, it was proposed to add 4 feet of masonry at top. This increased weight would help, though in a small degree, in increasing the F.S.

APPENDIX V-G

Further Comments of Irrigation and Power Team on Central Water and Power Commission's views dated the 13th October, 1959.

III. *Spillway Capacity* :

This is a very important question for the safety of the Dam. In view of some of the recent mishaps on account of inadequate capacity of the spillway provided in some dams in this region, it would not be safe to take any risk in this matter.

It has been stated that a thousand year flood at Vijayawada will be of the order of 15 lakh cusecs. During our discussion with Central Water and Power Commission on the 23rd June 1959 this figure was placed at 15.3 lakh cusecs. This flood has been worked out on the basis of the high flood discharges at Vijayawada as recorded, according to which the highest flood recorded so far was 10.6 lakh cusecs on 7th October, 1903.

It may, however, be mentioned that the highest flood as shown in the various project reports as have occurred on 7th October, 1903 is 11.94 lakh cusecs. Page 4 of the 1954 Nandikonda Project report, page 7 of Krishna Pennar Project report of 1951, page 13 of Khosla Committee's Report and pamphlet on New Krishna Barrage all show this discharge to be 11.94 lakh cusecs. This point had been referred to in our report but has not been touched by the Central Water and Power Commission in their note. The difference in the two figures is due to the fact that when Krishna Pennar Project report was prepared, certain model experiments were made to determine the coefficient of discharge. Those model experiments showed that the discharges at Vijayawada as recorded were less by 6.93 per cent to 28.86 per cent for various heights of the flood. It has been mentioned by the Project Authorities that those model experiments were not corectly made and that fresh model experiments are being made. If the fresh model experiments show that the discharges recorded are on the low side, corect discharges as given by the formula that may be obtained from the new model experiments should be taken into account for fixing the 1,000 year flood and the spillway capacity should be fixed on that basis.

The Central Water and Power Commission have stated that the design of the Dam provides a 10′ free board in the masonry section and 15′ free board in the earth section and that without a change in the present design, 15 lakh cusecs flood can be passed with the reservoir rising to about R.L. 594. It has further been stated that the free board on the masonry section can be regained by adding the height of the Dam and that for such raising, Dam section has been tested and is found safe and that the free board in the earth section after such raising is ample.

It may be mentioned that the question of the spillway capacity was considered by the Central Water and Power Commission in November, 1958 and a Memorandum was prepared. In that memorandum it was mentioned that the water level in the reservoir would rise to 594 for

a discharge of 13.85 lakh cusecs. It is now stated that 15 lakh cusecs can pass with the same level of 594. The two statements are inconsistent. If we have to cater for a discharge of 15.3 lakh cusecs which is 1,000 year flood on the present recorded discharges, the level may go up to 597. The present design of the dam will probably not be safe for this level. However, this is a matter of calculations, which can be done by the Central Water and Power Commission.

The Dam section may be safe for the higher water level with raised height of the dam and so may be the reduced free board on the earth section but it will be conceded that there will be encroachment on the margin of safety. The original free board and factor of safety should still be allowed in the dam design, as this is still possible in the present stage of construction. Otherwise it will be tantamount to saying that the original design was too liberal and the margin of safety now proposed is reduced.

It may be mentioned that the catchments of Godavari and Krishna are adjacent to each other. The catchment area of Godavari at Dowleshwaram is 1,16,000 square miles and that of Krishna at Vijayawada is 97,000 square miles. The discharge data for Godavari at Doleshwaram is available since 1895-96. On the basis of this data the highest flood discharge upto 1950-51 was 20.1 lakh cusecs in 1942. On the basis of this discharge and those of the other Northern and Central India Rivers, Kanwar Sain and Karpov have prepared an Envelope Curve for high flood discharge for these rivers. According to this curve the high flood discharge of Godavari works out to 21 lakh cusecs. However since 1950-51, the high flood discharge of Godavari has gone upto 28.3 lakh cusecs on 15th October, 1953, which is much outside the Envelope Curve of Kanwar Sain and Karpov. If co-efficient obtained from the discharge in formulae of Ali Nawaz Jang, Dickens, Ryots and Inglis are applied to Krishna River, its high flood discharge works out to 24-27 lakh cusecs.

Our object in referring to the Godavari high flood discharge is two-fold. The high flood discharge based on data of about 55 years from 1895-1950 was suddenly exceeded by over 8 lakh cusecs in 1953 which may not have been anticipated, if any design flood discharge had been based on previous data. The second reason is that the catchments of Godavari and Krishna are adjoining. There can, therefore, be a possibility of similar storms occuring in Krishna catchment. We would therefore suggest that no risks should be taken for designing spillway capacity for Nagarjunasagar Dam. The normal free-boards and other factors of safety should be reserved for any unprecedented flood of over 1,000 years' frequency.

Our recommendation will therefore be that spillway capacity at Nagarjunasagar may be provided for a 1,000 year flood at Vijayawada with modified co-efficient as may be found from new model experiments and that the factors of safety originally allowed should not be encroached upon at this stage. On the basis of high flood discharge of 15.3 lakh cusecs, the number of spillway spans required will be approximately 32 against 24, if the factors of safety are not to be encroached upon.

APPENDIX V-H

Extract on Spillway capacity from record of discussions held between Irrigation & Power Team & Central Water & Power Commission on 5-11-1959.

Regarding the spillway capacity the Central Water & Power Commission indicated that their designs of dams are based for 100 year flood to the corresponding F.R.L. and for 1,000 year flood corresponding to M.W.L. for which the section of the dam is tested for safety. In case of Nagarjunasagar 1,000 year flood had been previously worked out as 13.85 lakh cusecs and the maximum water level has been worked out as 594 on the basis of a continuous flood discharge of 13.85 lakh cusecs. The 1,000 years flood as worked out now is 15.31 lakh cusecs and it has now been worked out that on the basis of the broadest hydrograph the maximum water level will still be 594, for which the dam is safe. Shri Mathrani referred to 1953 floods of Godavari which have exceeded the previous recorded flood by over 7 lakh cusecs and that the high flood discharge of Koyna which was initially worked out as 1.13 lakh cusecs was finally revised to the peak rate of 4.94 lakh cusecs. The Team was, therefore, of the view that the spillway should be designed for a 1,000 years flood and a normal free board allowed for that flood to take care of any abnormal floods of frequency of over 1,000. Further the Team pointed out that the figure of 15.31 lakh cusecs for a 1,000 years flood was based on certain discharge coefficients at Vijayawada weir. Some model experiments had been made which had shown that the coefficient of discharge was higher than that adopted in the recorded discharges. Fresh model experiments have been proposed to be made. If as a result of the model experiments, the coefficients of discharge increase, adjustments for the 1,000 years flood should be made for the same and the spillway capacity designed accordingly.

APPENDIX V-1

RECORDED HIGH FLOOD DISCHARGE OF GODAVARI AT DOWLESHAWRAM

Serial No.	Year	Discharge momentary peaks in cusecs.	Serial No.	Year	Discharge momentary peaks in cusecs.
1	1904	8,87,115	23	1926	9,32,620
2	1905	7,95,401	24	1927	8,44,654
3	1906	10,77,710	25	1928	7,25,221
4	1907	12,27,602	26	1929	8,44,098
5	1908	10,36,331	27	1930	9,72,026
6	1909	9,01,495	28	1931	9,54,304
7	1910	9,63,022	29	1932	9,32,637
8	1911	11,43,984	30	1933	10,21,081
9	1912	11,86,248	31	1934	10,28,550
10	1913	9,69,100	32	1935	8,08,950
11	1914	11,41,219	33	1936	10,75,256
12	1915	10,66,000	34	1937	7,84,639
13	1916	9,14,600	35	1938	10,10,750
14	1917	9,35,530	36	1939	8,96,280
15	1918	7,18,000	37	1940	17,90,840
16	1919	6,78,000	38	1941	6,25,700
17	1920	5,27,570	39	1942	21,07,660
18	1921	9,98,378	40	1943	6,34,994
19	1922	8,24,126	41	1944	17,94,030
20	1923	5,54,507	42	1945	11,64,375
21	1924	6,28,667	43	1946	12,50,260
22	1925	7,95,776	44	1947	11,16,607

APPENDIX V-I (*concld*)

Serial No.	Year	Discharge momentary peaks in cusecs	Serial No.	Year	Discharge momentary peaks in cusecs
45	1948	6,70,709	53	1956	15,71,170
46	1949	11,18, 558	54	1957	17,55,310
47	1950	11,53,463			
48	1951	8,46,323			
49	1952	5,25,643			
50	1953	*30,00,000			
51	1954	10,83,686			
52	1955	13,64,150			

* As intimated by the State

APPENDIX VI

Statement of hire rates of some earth moving machinery on the basis of which debits are raised to the work.

1. Motorised Scrapers 12 14 Cu. yards Capacity

I. Depreciation charges per hour.

Cost of machine	Rs. 1,67,000
Less cost of original value of tyres	Rs. 23,800
TOTAL amount to be depreciated	Rs. 1,43,200
Life of machine = 12,000 hours	
∴ Depreciation per hour = Rs. 11·94	
Cost of tyres, tubes etc. = Rs. 23,800	
Life of tyres tubes, etc., = 2,500 hours.	
Depreciation of tyres and tubes per hour	Rs. 9·52
∴ TOTAL depreciation per hour = 11·94 + 9·52	Rs. 21·46

II. Repairs and Replacements charges per hour.

@60% of depreciation = 60/100x11·94 = ...	Rs. 7·16
Repairs and replacement of Tubes and tyres @ 10% = 10/100x9·52 =	Rs. 0·95
TOTAL PER HOUR	Rs. 8·11

III. Fuels and Lubricants per hour.

3 gallons of H.S.D. oil @ Rs. 2/- per gallon = ...	Rs. 6·00
Lubricants and grease @ 50% of H.S.D. oil = ...	Rs. 3·00
TOTAL	Rs. 9·00

Based upon the average actual consumption and the rates and Costs Committee recommendations, 3 gallons of H.S.D. oil per hour has been assumed above.

IV. Labour charges per hour.

(*a*) $\frac{\text{∴ Total hire charges rate per hour}}{\text{(excluding interest)}}$ = ... Rs. 1·80

TOTAL of items I to IV = 40·37 or say .. .. Rs. 40·40

(*b*) *Hire charges per hour including interest*

Interest per hour @ 5% of capital cost per year as per P.W.D. Code =

$$\frac{5}{100} \times 16{,}7000 \times \frac{1}{2000} =$$ Rs. 4·20

TOTAL hire rate including interest = 40·40 + 4.20 = Rs. 44·60

APPENDIX VI *(contd.)*

4. REAR DUMPERS 14 Cyds. 250 H.P.

I. Depreciation charges per hour	Rs.
Cost of machine	2,18,000
Less original cost of tyres and tubes	20,000
∴ TOTAL amount to be depreciated	1,98,000
Life of machine = 15,000 hours.	
Depreciation per hour = Rs. 13·20	
Cost of tyres and tubes etc., = Rs. 19,578	
Life of tyres and tubes etc., = 2500 hours	
Depreciation of tyres and tubes etc., per hour = ...	7·83
∴ TOTAL depreciation per hour = 13·20 + 7·83 = ...	21·03
II. Repairs and replacements charges per hour	
@ 60% of depreciation of machine	7·92
Repairs and Replacements of tyres and tubes @ 10% = 10/100x7·83 =	0·78
TOTAL CHARGES	8·70
III. Fuels and Lubricants charges per hour.	
3½ gallons of H.S.D. oil @ Rs. 2/- per gallon	7·00
Fuels and lubricants @ 50% of above	3·50
TOTAL	10·50

Based upon the average actual consumption and Rates and Costs Committee Report recommendations 3½ gallons of H.S.D. Oil per Hour is assumed above

IV. Labour Charges per hour.

(*a*) $\frac{\text{∴ Total hire charges per hour}}{\text{(Excluding interest)}}$ = 1·80

Total items I to IV = 42·03 or .. .. 42·00

(*b*) *Total hire charges per hour including Interest*

Interest per hour @ 5% of capital cost per year as per P.W.D. Code.

$\frac{5}{100} \times 2{,}18{,}000 \times \frac{1}{2000}$ = 5·45

∴ TOTAL hire charges per hour including interest = 42·03 + 5·45 = 47·48 or say 47·50

13. TRACTOR 40-45 H.P. (RUBBER TYRED)

I. Depreciation.	
Cost of Machine	13,600
Life of machine = 10,000 hours	
Cost of tyres and tubes etc., = Rs. 2,080	
Net amount to be depreciated = 13,600—2,080 = ...	11,520

APPENDIX VI *(concld.)*

	Rs.
∴ Depreciation of machine per hour = 11,520/1,0000 = ...	1·15
Life of tyres and tubes etc., = 2,500 hours.	
Depreciation of tyres, tubes etc., per hour = 2,080/2,500 .	0·83
∴ TOTAL depreciation per hour	1·98
II. Repairs and maintenance charges per hour of Machine.	
@ 60% of depreciation = 1·15 × 06 = ...	0·69
Repairs and replacements of tyres, tubes, etc., @ 10% of depreciation = 10/100x0·83 = ...	0·08
∴ TOTAL PER HOUR	0·77
III. Fuels and Lubricants.	
1½ gallons of H.S.D. oil @ Rs. 2 per gallon	3·00
Lubricants and grease @ 50% of above	1·50
	4·50
Proportionate value of H.S.D. Oil is assumed above as per the Rates and Costs Commitee Report.	
IV. Labour Charges per hour.	
Hire charges per hour exclusive of interest = ...	9·00
Total of items of I to IV above = 9·05 or	
Hire charges per hour including Interest	
Interest per hour @ 5% of capital cost per year as per P.W.D. Code—& @2,000 working hours per year = $\frac{5 \times 13,600}{100 \times 2000}$	0·34
∴ TOTAL hire per hour including interest = 9·05 + 0·34 = 9·39 or say	9·50

APPENDIX VII

Office of he Chief Engineer, for Irrigation,
Public Works Department, Kurnool.

D.O. No . 135 CAMP — CAMP NEW DELHI, 4TH SEPT. 1954

My dear Kanwar Sain,

Shri D. V. Rao and myself examined the estimates for the Nandikonda Dam and the Right and Left Side Canals, worked the changes that are required to fit the 13,000 cusec canal suggested this afternoon for the Right Side Canal, and 11,000 cusec canal for the Left Side, up to miles 140 and 108 respcetively and find that the changes noted below will be necessary and adequate :

Right Side Canal :

	Rs. lakhs
Estimate as per page 170 of Joint Project report	3,160
Deduct cost of lining=5 crores	
Cost of less E.W. =3 crores	
Saving in cost of Bridges and other works	860
Net eost of Right Side Canal	2,300

Left Side Canal :

Estimate as per page 172 of Joint Report	2,179
Deduct for cost of lining ..160·5 lakhs	
Savings in other items .. 18·5 lakhs	
Net cost of Left Side Canal	2,000
Cost of Dam etc., unaffected items	3,208
TOTAL cost of Stage plan	7,508

The irrigation under this will be as detailed below. The Revenue realisable at Rs. 15 for conversion from dry to wet, Rs. 10 for irrigated dry and Rs. 7.50 for second wet crop, and Rs. 7.50 over the present rate for precarious wet to wet as annual assessment and the capital realisable as betterment charge at Rs. 200, 100 and 50 for a second wet crop in the Krishna Delta, and 50 for conversion from precarious wet to wet are also shown.

		Lakh acres.	Rs.	Rs.
Right side Canal ..	Wet	3·2	48,00,000	6,40,00,000
	Dry	6·5	65,00,000	6,50,00,000
Left Side Canal ..	Wet	6·7	1,00,50,000	13,40,00,000
	II Crop	1·2	9,00,000	—
Krishna	New I Crop	1·5	22,50,000	3,00,00,000
Delta	II Crop	4·5	33,75,000	2,25,00,000
TOTAL ..		23·6	2,78,75,000	31,55,00,000

APPENDIX VII (*concld.*)

Deducting betterment from the capital, the net cost of the Project is 7,508—3,155 =4,353 lakhs.

Deduct from the revenue 5% for collection charges .. .. Rs. 13,93,750

and for maintenance at Rs. 2·50 per acre of Ayacut on 17·9 lakh acres. „ 44,75,000

Total „ 58,68,750

and the net Revenue is : Rs. 278,75,000—58,68,750

Or

Rs. 220,06,250.

Yielding a return on the net capital of 5.05 per cent.

We have examined the matter very carefully and we are satisfied that the estimates furnished will not vary beyond the permissible limit of ten per cent plus or minus and that these are as near an accurate estimate as is possible.

We trust the Technical Committee will be satisfied with the figures furnished and will recommend the scheme for sanction by the Planning Commission and the Government.

Yours sincerely,

D. V. Rao,
Chief Engineer Irrigation,
Hyderabad State.
4-9-1954.

L. Venkatakrishna Ayyar,
Chief Engineer, Irrigation,
Andhra State.
4-9-1954.

To

Shri Kanwar Sain,

Chariman, C.W. & P.C., New Delhi.

APPENDIX VIII

PLANNING COMMISSION

Summary Record of the Discussions held in the Planning Commission on 24th February, 1955 regarding the Nandikonda Project.

Present:

Planning Commission

Shri V. T. Krishnamachari
Shri G. L. Nanda
Shri S. V. Ramamurthy
Shri B. R. Tandan
Shri Tarlok Singh
Shri Yadava Mohan
Shri M. R. Kothandaraman
Dr. D. K. Malhotra
Shri K. Mitra
Shri M. M. Thomas
Shri P. C. Suri
Shri C. S. Parthasarathy

Government of Andhra

Shri C. M. Trivedi, Governor
Shri K. N. Anantaraman, Secretary, P.W.D.
Shri L. Venkatakrishna Iyer, Chief Engineer

Government of Hyderabad

Shri B. Ramakrishna Rao, Chief Minister
Shri D. V. Rao, Chief Engineer

Ministry of Irrigation and Power

Shri J. L. Hathi, Deputy Minister
Shri T. Sivashankar, Secretary
Shri Kanwar Sain, Chairman, C.W. & P.C.
Shri M. D. Mithal, Member, C.W. & P.C.
Shri S. Venkataraman, Deputy Secretary
Shri M. G. Hiranandani, Director, C.W. & P.C.

Ministry of Finance

Shri S. Ratnam, Joint Secretary
Shri C. S. Krishnamurthy, Deputy Secretary
Shri Rathee, Deputy Secretary
Shri S. Ramier, Finance Officer

The following matters connected with the Nandikonda Project were discussed :—

Modifications required in the Project and Consequent Revision of Estimates.

2. At the outset, Shri V. T. Krishnamachari made it clear that it should be understood that the areas proposed to be irrigated by the Nandikonda Project are the clearly defined areas agreed to after discussions with the Andhra representatives, and that acceptance of the present scope of the Nandikonda Project (Stage I) involved no commitments, whatever, in regard to other projects on the Krishna. As regards the estimates of cost, the Chief Engineer (Irrigation), Andhra, maintained that, due to fall in prices and consequent reduction in the schedule of rates by 10%, he would stand by his original

cost estimates. The C.W. & P.C. thought the estimates were likely to be exceeded under various heads.

Financing and Sharing of Costs

3. The sharing of costs of common works, as proposed in the joint report on the Nandikonda Project, was agreed to. Separate Agreement will be entered into by the Government of India with each State Government (*i.e.*, Andhra and Hyderabad) in respect of (*i*) its share of costs and (*ii*) advance of loans by the Central Government to the State Governments and (*iii*) the terms for repayment. The State Governments undertook to charge betterment fees and water rates in accordance with the proposals in the Joint Project Report.

4. The Chief Minister, Hyderabad said that the development of the commanded area under the project should be planned in the initial stages and expenditure provision made. Shri V. T. Krishnamachari pointed out that National Extension Blocks should be organized as soon as the Nandikonda project was sanctioned so that deveolpment of Land for irrigation might be financed through cooperatives, etc. The State Governments should also take steps to see that every village excavated the canal system in its own area. By this means, the wages paid in every village would be available for development provision for expenditure for such ancillary purposes could not be made in the main project estimates.

Agency for Constructions

5. This item was discussed in a general way. The important point was the authority through whom orders of sanction for the dam and appurtenant works should be issued with whom contracts would be entered into. The Irrigation and Power Ministry will prepare a note, embodying the result of the talks, for circulation.

Preliminary arrangements for starting works

6. This was not taken up for discussion.

APPENDIX IX

Approval by the Nagarjunasagar Control Board to the revised estimate of Rs. 91.12 crores vide item (11) of the proceedings of Control Board XX meeting held on 30th December, 1958.

ITEM 11 :—*Consideration of Progress in the sanction of the Project Estimate.*

The Board approved of the revised Project Estimate of Rs. 91.12 crores as in Appendix IV and desired that revised financial statements be prepared on the lines indicated by the Government of India *i.e.* on the basis of the Second Plan allotment of Rs. 32.30 crores, the balance of the funds being found in the Third Plan period.

The Board considered that there were some items in the Project Estimate for which the Project was justifiably entitled to take some credit resulting in reduction of capital expenditure, *e.g.*, Railway line from Macherla to Damsite, approach roads, road bridge across the Krishna, etc. and that a decision on these matters would have to be taken at the appropriate time.

Revised Cost of Project Estimate

Amount of original estimate sent up for sanction	Rs. 88·18 crores
Deduct:- Cost of Kavali—Kanupur Canals, agreed to be dropped	Rs. 1·61 ,,
Total ..	Rs. 86·57 crores

I. PROBABLE EXCESSES

1. On account of increase in cost of cement, steel, Oils., etc.

	Rs. lakhs
Cement :	
(*a*) Dam	331·50
(*b*) Right Canal	12·80
(*c*) Left Canal	8·16
Steel :	
(*a*) Dam	21·00
(*b*) Right Canal	10·50
(*c*) Left Canal	8·40
Oils :	
(*a*) Dam	12·00
(*b*) and (*c*) Canals	24·30
TOTAL ..	428·66 (or say 4·29 crores.)

APPENDIX IX (*concld.*)

	Rs. lakhs
2. On account of changes of policy	
Provision for field channels on the Left Canal to ensure uniformity with Right Canal	26·00
	(or 0·26 crores.)
3. On account of other items	
(*a*) Additional irrigation of 1·5 lakh acres 1st crop and 1·5 lakh acres 2nd crop— for distribution system.	150,00
(*b*) Excess on account of Cross Drainage works	16·00
(*c*) Excess under Land and compensation (Left Canal)	15·00
(*d*) Excess on account of re-allocation of monuments	6·00
(*e*) Excess under provision for Left Canal distributaries	5·00
Total=	192·00
	(=1·92 crores.)
GRAND TOTAL	Rs. 93·04 crores.

II. PROBABLE SAVINGS :

	Rs. lakhs
1. Dam	
(*a*) Dewatering & Coffer Dams	20·00
(*b*) Railway lines	10·00
(*c*) Replacement of concrete by 1:3 cement mortar	40·40
(*d*) Reduction in radius of spillway	6·00
(*e*) Procurement of surplus machinery	40·00
2. Canals :	
(*a*) Procurement of surplus machinery	30·00
(*b*) Savings due to reduction in the provision for contingencies	21·00
(*c*) Savings due to Departmental working and Public participation	25·00
	192·00
	1·92 crores
TOTAL OF ESTIMATE	Rs. 91·12 crores)

APPENDIX X-A

Statement II-B (For the year 1957-58)—Revised...

WORKING EFFICEINCY OF MACHINES AT NAGARJUNASAGAR PROJECT RIGHT CANAL

Serial No.	Name of machine	Quantity	Actual working hours	Total days per year	Days lost due to late commiss-ioning on works (due to late receipt)	Days lost due to rain (Assumpt-ion)	Net Scheduled days for the year Cols. (5)-(6+7)	Remarks
1	2	3	4	5	6	7	8	9
1	N.W. Model 80-D Excavator No. I ..	1 no.	744	300	—	50	250	
2	N.W. Model 80-D Excavato4 No. II ..	1 no.	—	300	300	—	Nil	
3	Euclid Rear dumpers	7 nos.	2,968	2,100	100	350	1,650	Out of the 7 nos. of dumpers 2 nos. were received on works in June 57.
4	Ditto	8 nos.	—	2,400	2,400	—	Nil	
5	Cat. MW-20 bottom dumpers	10 nos.	—	3000	3,000	—	Nil	
6	Euclid B5 FDT bottom dumpers	3 nos.		900	900	—	Nil	
7	Motorised Scrapers—							
	(a) Let Westing house Model C scrapers	2 nos.	1,264	600	100	100	400	Transferred to N.S. Left Canal works by the end of January, 1958.

APPENDIX X-A (*contd*)

1	2	3	4	5	6	7	8	9
	(*b*) Cat DW-15 Motorised scrapers ..	3 nos.	3,456	900	—	150	750	
	(*c*) Ditto	3 nos.	3,495	900	225	150	525	Commissioned in July, 57.
	(*d*) Let Westing house Model B scrapers	2 nos.	1,654	600	200	100	300	Commissioned by the end of September, 57.
7	(*a*) to (*d*) TOTAL Mortorised scrapers ..	10 nos.	9,869	3,000	525	500	1,975	
8	Crawler tractors—							
	(*a*) TD-24 Crawler Tractors	2 nos.	2,740	600	—	100	500	
	(*b*) Ditto.	2 nos.	1,570	600	150	100	350	Commissioned in July, 57.
	(*c*) Ditto	4 nos.	—	1,200	1,200	—	—	
	(*d*) TD-18 Crawler tractors	3 nos.	2,349	900	175	150	575	I nos. was commissioned in July, 57 and 1 No. in July, 57.
	(*e*) TB-18 Crawler Tractors	1 no.	560	300	175	200	125	Commissioned in Novemer, 57.
	(*f*) Cat. D-8 Crawler Tractors	1 no.	1,031	300	75	50	175	Commissioned in June, 1957.
	(*g*) Ditto.	3 nos.	1,641	900	525	—	375	Commissioned in November, 57.
	(*h*) Ditto	1 no.	—	300	300	—	—	

(*i*) HD-58 Crawler Tractors	2 nos.	2,344	600	—	100	500	
(*j*) B.T.D.-6 Cwraler Tractors	7 nos.	10,850	2,100	—	350	1,750	
(*k*) HD-15 Crawler Tractors	1 no.	296	300	—	50	250	
(*l*) Ditto	1 no.	—	300	300	—	—	
8 (*a*) to (*l*) TOTAL of Crawler Tractors ..	28 nos.	23,381	8,400	2,900	900	4,600	
9 Cat D-7 Crawler Tractors							
(*a*) Cat D-7	1 no.	1,406	300	—	50	250	
(*b*) Cat D-7	1 no.	872	300	175	—	125	Commissioned in November, 57.
9 (*a*) to (*b*) TOTAL of Cat. D-7 Crawler Tractors	2 nos.	2,278	600	175	50	375	
10 Fowler challenger tractors	2 nos.		600	600	—	—	
11 Caterpiller Rubber tyrod tractor hauling unit	1 no.	203	300	150	—	150	
TOTAL ..	73 nos.	39,443 hours.	21,900	11,050	1,850	9,000 days	

Average working efficiency of the machinery=39443/9000=4 hrs. 23 mts. per day.

APPENDIX X-B

Statement II-B (for the year 1958-59)—Revised

WORKING EFFICIENCY OF MACHINES AT NAGARJUNASAGAR PROJECT RIGHT CANAL

Serial No.	Name of the Machine	Quantity	Actual working hours	Total days per year	Days lost due to transfer to other units	Days lost due to commission, late receipt and strike etc.	Days lost due to rain	Net scheduled days	Remarks
1	2	3	4	5	6	7	8	9	10
1	N.W. Excavator Model 80-B I	1	627	300	—	150	50	100	
2	N.W. Excavator Model B-80 II (standby)	1	65	300	—	213	50	37	
3	Euclid Rear Dumpers	7	5,810	4,500	150	2,400	750	1,200	
4	Ditto	8							
5	Cat.D-W. 20 Bottom Dumpers	10	2,106	3,900	—	2,688	650	562	
6	Euclid B.P.D. Do.	3							
7	Motorised Scrapers	10	8,692	3,000	75	650	500	1,775	
8	Crawler Tractors	35	23,978	10,500	—	5,150	1,750	3,600	
9	Euclid Loader	1	282	300	—	188	50	62	
10	Hydraulic Dozers	4	600	1,200	—	950	—	250	Received in IV Qr.
	Total ..	80	42,160	24,000	225	12,389	3,800	7,586	

Average working Efficiency of the Machinery for day=42,160/7,586=5 hrs. 33 mts. per day.
Percentage of Efficiency=66·6%

sd/-. SUPERINTENDENT,
Field Machinery Division.

NOTE.—As working of 2 shifts have been started now the efficiency and rate of utilisation of machinery will be further improved in 1959-60.

APPENDIX XI-A

Statement II-B (for the year 1957-58)—Revised

WORKING EFFICIENCY OF MACHINES AT NAGARJUNASAGAR PROJECT LEFT CANAL

Serial No.	Name of Machine	Quantity	Actual working hours	Total days per year	Days lost due to late commissioning on works (due to late receipt)	Days lost due to rain (Assumption)	Net scheduled days for the year Col. 5-(6+7)	Remarks
1	2	3	4	5	6	7	8	9
1	Cater Pillar D-8 Tractors	2	754	600	—	100	500	
2	T.D. 24 Tractors	2	368	600	—	100	500	
3	I.H.B.R.D. 6 Tractors	9	6,804	2,700	—	450	2,250	
4	Fordson Major Tractors	6	8,118	2,100	—	350	1,750	
5	David Brown Tractors	1						
6	Zettlemeyer D.R. Rs.	2	1,952	600	—	100	500	
7	C. Model Scrapers	4	1,828	1,200	450	—	750	
8	Catter Pillar D-7 Tractors	2	334	600	525	—	75	
	Total ..	28	20,158	8,400	975	11,00	6,325	

Average working efficiency of machinery per day=20,158/6,325=3 hrs. 11 mts.

sd/- SUPERINTENDENT
Field Machinery Division.

APPENDIX XI-B

Statement II-B (For the year 1958-59)—Revised

WORKING EFFICIENCY OF MACHINES OF NAGARJUNASAGAR PROJECT LEFT CANAL

Serial No.	Name of Machine	Quantity	Actual working hours	Total days per year	Days lost due to late commissioning on works (due to late receipt)	Days lost due to rain (Assumption)	Net scheduled days for the year Col. 5-(6+7)	Remarks
1	2	3	4	5	6	7	8	9
1	Cat. Pillar D-8 Tractor	3	1,935	900	150	100	650	
2	TD-24 Tractors	2	548	600	—	100	500	
3	'C' Model Scraper	2	1,524	600	—	100	500	
4	Cat. D-7 Tractors	5	3,592	1,500	1,025	115	360	
5	A.C.H.D. 21 Tractors	1	259	300	25	50	225	
6	A.C.H.T.S. 60 Scrapers	5	3,608	1,500	125	250	1,125	
7	A.C.H.D. 16 Tractors	5	1,427	1,500	600	330	570	
8	A.C.H.D. 11 Tractors	2	1,572	600	275	50	275	
	TOTAL	25	14,765	7,500	2,200	1,095	4,205	

Average working effiicency of machinery per day=14,765/4205=3 hrs. 30 mts.
Percentage of efficiency=43·7%

NOTE.=One Lima shovel excavator and four Rear Dumpers are excluded from the above statement, as these are engaged only for experimental purpose.

N.B.—As working of 2 shifts have been started now the efficiency and rate of utilisation of machinery will be further improved in 1959-60.

sd/- SUPERINTENDENT,
Field Machinery Division.

APPENDIX XII

Statement showing working expenses for Major Irrigation works in the (Old) Madras State for the year 50-51. (extracted from the "Administration Report" for 50-51. Part II-B) (Statistical Tables)

Serial No.	Name of work	Command (Lakhs Acres)		Annual Maintenance charges	
		Gross	Irrigation	Total Rs. lakhs	Per acre (net) (5)/(4)
1	2	3	4	5	6
1	Cauvery Delta	16·60	8·64	26·65	3·85
2	Godavari Delta	11·8	8·73	27·87	3·30
3	Krishna Delta	—	10·50	37·50	3·57
4	Cauvery Mettur Project	4·97	3·32	6·92	2·08
5	Pennar River System	2·59	1·70	5·69	3·35
6	Kurnool-Cudapah Canal	3·83	1·30	4·5	3·20
7	Lower Coleroon Anicut	1·05	0·86	3·78	4·40
8	Kattalai Scheme	0·79	0·67	1·50	2·24
9	Palar Anicut	1·41	0·80	1·07	1·34

APPENDIX XIII

Copy of D.O. No. COPP/I&P/MP/NS-41, dated the 15th January, 1959, from Irrigation and Power Team to the Administrator, Nagarjunasagar Control Board, Barkatpura, Hyderabad Dn.

I am enclosing herewith a note on Savings and Excesses on the Right Bank and Left Bank Canals on the basis of the information which has been received from time to time.

2. It would be seen that the excesses and savings that are being worked out are with respect to the 1956 Project estimate but the changes, that have been made in the design of the canals which will affect the quantities and the cost very materially, are not being taken into account at all. In case any fresh estimates have been prepared on the basis of the new designs, they may kindly be supplied.

3. The Left Bank Canal is now being designed for 15,000 cusecs against 11,000 cusecs as shown in the Project. The cost of the masonry structures will, therefore, be materially affected on this account.

4. There is a provision of Rs. 92.76 lakhs under special tools and plant for the canals and the net provision that is proposed to be retained is Rs. 42 lakhs only. It would be of interest to know how the remaining cost will be written off as depreciation to various items of work. It would seem to be advisable to have fresh project estimates prepared immediately for the designs that are being followed.

5. Could you kindly let me have the comments of the Project authorities on the various points raised in the note ?

Note on savings and excesses on the Right Bank and Left Bank Canals of Nagarjunasagar Project.

The 1956 Project estimate cost for Right Bank Canal is Rs. 29.33 crores and that for Left Bank Canal is Rs. 23.40 crores. In view of the increase in rates of cement, steel and oils etc. these estimates have been reviewed at various stages. In the XVIIth meeting of the Nagarjunasagar Control Board held on 31st May, 1958 following excesses and savings were shown :—

Right Bank Canal :

Excess -	Rs. Lakhs
Cement and steel	53·00
Distributaries for Krishna Delta	150·00
Excess on Chandravanka Aqueduct	16·00
Earth work in the main canal due to variation of soil ..	100·00
Excess in the cost of tunnels	75·00
TOTAL	394·00
Deduct savings on account of omission of one tunnel.. ..	75·00
Net Excess	319·00

APPENDIX XIII (*contd.*)

Revised Cost of Right Bank Canal.

	Rs. crores
Project estimate	29·33
Probable excess	3·19
TOTAL	32·52

Left Bank Canal :

Excess

	Rs. Lakhs
Cement and steel	30·00
Land compensation—main canal	15·00
Land compensation for distributaries	20·00
Earth work in main canal	100·00
TOTAL	165·00

Revised cost of Left Bank Canal.

	Rs. crores
Project estimate	23·40
Probable excess	1·65
TOTAL	25·05

Total cost of both canals Rs. 32·52+Rs. 25·05=Rs.57·57 crores.

These figures were further revised in the XIXth meeting of the Nagarjunasagar Control Board held on 18th October, 1958.

Right Bank Canal :

Excess

	Rs. lakhs
Extra cost of cement and steel	53·00
Provision for distributaries in Krishna Delta	150·00
Excess on Chandravanka aqueduct	16·00
Excess in cost of earth work due to variation in soil	100·00
Excess in cost of tunnels	75·00
TOTAL	394·00

Savings

Due to omission of one tunnel	75·00
Savings on account of procurement of surplus machinery from other R.V. Projects.	29·00
TOTAL	104·00
Net Excess	290·00

APPENDIX XIII (*contd.*)

Revised cost of Right Bank Canal.

	Rs. crores
Project estimate	29·33
Probable Excess	2·90
TOTAL	32·23

Left Bank Canal.

Excess

	Rs. lakhs
Extra cost of cement and steel	30·00
Probable excess under land compensation	15·00
Provision for land compensation for distributaries	20·00
Excess in cost of earth work in main canal	100·00
TOTAL	165·00

Savings

Due to procurement of surplus machinery from other R.V. Projects.	21·00
Net excess	144·00

Revised estimated cost of Left Bank Canal.

	Rs. crores
Project estimate	23·40
Probable excess	1·44
TOTAL	24·84

Total cost of both Canals = 32·23 + 24·84 = 57·07 crores.

These figures have been further reviewed by the Project Authorities for the next meeting of the Nagarjunasagar Control Board.

Probable excess on both canals.	Rs. Lakhs.
Cement Right Bank Canal	12·80
Cement Left Bank canal	8·16
Steel Right Bank Canal	10·50
Steel Left Bank Canal	28·40
P.O.Ls.	24·30
Provision for field channels on the Left Bank Canal to ensure uniformity with Right Bank Canal.	26·00
Distributaries for 1·5 lakh acres First crop and 1·5 lakh acres Second crop of Krishna Delta.	150·00
Excess on account of cross drainage works (Chandervanka Aqueduct).	16·00
Excess under land compensation of Left Bank Canal	15·00
Excess under provision for Left Bank Canal distributaries	5·00
TOTAL	216·16

APPENDIX XIII (*contd.*)

Probable Savings

Procurement of surplus machinery from R.V. Projects	30·00
Savings due to reduction in the provisions for contingencies ..	21·00
Savings due to departmental working and public participation ..	25·00
TOTAL	76·00
Net Excess	200·16

Revised estimated cost of Right and Left Bank Canals

	Rs. crores
Right Bank Canal	29·33
Left Bank Canal	23·40
Probable excess	2·01
TOTAL	54·74

The overall cost of the project has varied as under :—

	Whole project	Cost of canals
	Rs. crores	Rs. crores
1956 Project estimate	86·57	52·73
May 1958 review	95·24	57·57
October 1958 review	94·24	57·07
Latest review	91·12	54·74

These changes naturally raise the issue whether the latest figures are realistic or otherwise.

2. At the out-set it may be mentioned that the designs of both the Right and left Bank Canals have been entirely changed with respect to 1956 Project estimate. The most important change that has been made in the design of the Right Bank Canal is that it was originally intended to be a lined canal and now it is to be constructed as an unlined canal in the first phase. The 1956 Project estimate has been based on the lined section excepting that the lining has been omitted. The project design of the Right Bank Canal at the head to carry 21,000 cusecs was 155′ bed width and 20′ depth. This design has been changed and the canal is now proposed to be constructed of 250′ bed width and 15′ depth. This change in the design will not only affect the cost of earth work but of all the masonry structures also.

3. Similarly the Left Bank Canal was originally designed for the final discharge of 11,000 cusecs; now it is being designed for 15,000 cusecs at the head. The 1956 Project provides for a canal section of 134′ × 15′. The new designs is 95′ × 22′. Previously all the masonry structures were designed for a discharge of 11,000 cusecs now they will

APPENDIX XIII (*contd.*)

have to be designed for a discharge of 15,000 cusecs. The estimate will, therefore, very materially change.

4. As a matter of fact, there are no project estimates for the two canals according to the design that is being adopted. It is not known how the changes in the designs will affect the original estimate, to which savings and excesses are being referred.

5. In the first and the second reviews, excess on account of cement and steel was shown as Rs. 83 lakhs. Now it is shown as Rs. 64.64 lakhs which includes also the excess on P.O.Ls.

6. In the first and second reviews the excess on earth work in both the canals due to variation of soil was shown as Rs. 200 lakhs. In the last review no such excess is shown and no reasons are assigned whether any excess will occur due to variation of soil or quantities. It will be more realistic to work out fresh quantities of earth work instead of giving any arbitrary lump sum excesses.

7. In the first and second reviews the excess in cost of tunnels was shown as Rs. 75 lakhs and savings were shown as Rs. 75 lakhs on account of omission of one tunnel. In the latest review, no mention is made of either excesses or savings. Probably this is due to the reason that excesses balance the savings, so they are not mentioned. It, however, appears to be very necessary to know what will be the actual excesses on tunnels as the rates provided in 1956 Project estimate have been very considerably exceeded. The estimate provides Rs. 125 per unit for tunnel excavation while the tender provides Rs. 159. Similarly the rate for concrete lining of the tunnel in the estimate is Rs. 270 and in the tender it is Rs. 450. The excess due to increase in rates both on Right and Left Bank Canal tunnels will be very much more than Rs. 75 lakhs as originally shown and the savings on account of omission of one tunnel will be very much less. Another factor for further excesses in the case of the Left Bank Canal will be that it is now designed for 15,000 cusecs instead of 11,000 cusecs as provided in the project. Has this increase in discharge received the sanction of Government of India? Further it may be menioned that 1954 Project provided Rs. 3,70,68,000 for two tunnels and the 1956 Project provided Rs. 2,89,70,000 for the same two tunnels. The cost of one tunnel at the head for a length of 1,53,000 feet and carrying a discharge of 11,000 cusecs has been worked out as Rs. 1,39,55,300 and the same cost has been adopted for a tunnel lower down of approximately same length to carry a discharge of 2,059 cusecs. This method of working out the cost seems to be rather arbitrary. Besides, there seems to be some confusion in the project estimate in working out the rate for the first tunnel. The rate for the enlargement has been shown as Rs. 4/9/2 per unit and the units shown are 8323.20. The cost is shown as Rs. 67,41,800. All these figures cannot be followed. It would appear that even the Project estimate is not accurate in its detail. Besides the tunnel at the head will have now to be designed for 15,000 cusecs instead of for 11,000 cusecs are provided in the Project. This will increase the cost.

APPENDIX XIII (*contd.*)

8. In all the three reviews, a provision of Rs. 150 lakhs has been made for the distributaries for an ayacut of 1.5 lakh acres in Krishna Delta, i.e. at the rate of Rs. 100 per acre. It may be mentioned that in case of the Left Bank Canal there is a provision of Rs. 54 per acre for distributaries and branches and in case of Right Bank Canal there is an average provision of Rs. 82 per acre. In case of Krishna Delta distributaries Rs. 100 per acre is being provided. These variations need to be reconciled. If for a wet ayacut in Krishna Delta the cost of distributaries is expected to be Rs. 100 per acre it would not be less than that amount for Left and Right Bank Canals where there is both dry and wet cultivation.

9. In case of Left Bank Canal excesses of Rs. 15 lakhs and Rs. 20 lakhs have been shown for land compensation for main canal and distributaries respectively in the first and second reviews, while in the final review excess of only Rs. 15 lakhs has been shown in the land compensation for the main canal. The total provision for land compensation in the 1956 Project estimate for Left Bank Canal is Rs. 15.45 lakhs. This will certainly be inadequate. As regards the excess for land compensation on distributaries, it will perhaps be provided in the average rate per acre for distribution system.

10. In all the three reviews an excess of Rs. 16 lakhs has been shown on Chandravanka aqueduct for which estimates have been prepared on the basis of the design that is being adopted for the Right Bank Canal. Estimates have been prepared for the Hallia aqueduct in 12th mile on the Left Bank Canal also. There is an excess of about Rs. 14 lakhs in that estimate too. This has not been taken into account. These are the only two main works for which estimates have been prepared. It is, therefore, very likely that there will be similar excesses on other masonry works on the canals also.

11. In the second review, savings of Rs. 29 and Rs. 21 lakhs on account of procurement of surplus machinery from other river valley projects are provided in case of Right and Left Bank Canals respectively. In the last review the savings are shown as Rs. 30 lakhs in case of both the canals against Rs. 50 lakhs in the previous review. It may be mentioned that a net provision under special tools and plant for Right Bank Canal is Rs. 47 lakhs only. If savings of Rs. 29 lakhs are expected, the net provision will be Rs. 18 lakhs, only. Similarly in case of Left Bank Canal, the net provision is Rs. 45 lakhs and if savings of Rs. 21 lakhs are expected the net provision will remain only Rs. 24 lakhs. Considering the large expenditure on special tools and plant for both these canals that is being incurred, it is doubtful if any such savings will occur under this head. It will be of interest to have consolidated estimates for special tools and plant purchased already and to be purchased for both the canals, along with the list of works to which the depreciation on such special tools and plant will be charged. It is seen that while approaching the Control Board for purchase of machinery no calculations are given justifying the necessity for the same and how the depreciation charges will be debited to works and what will be the residual value left under the project.

APPENDIX XIII (*contd.*)

12. In the last review, an excess of Rs. 5 lakhs has been shown for Left Bank Canal distributaries for a mistake of 10,000 acres in the ayacut area. The ayacut is shown as 6.70 lakh acres but the provision in the 1956 Project estimate has been based on 6.6 lakh acres The provision for this item will have to be made on the same average rate basis, which will be adopted for all the systems.

13. In the last review savings due to reduction in the provision of contingencies have been shown as Rs. 21 lakhs. Perhaps it is too early to count on savings on contingencies in view of changes already made in the design.

14. In the last review savings due to departmental working in public participation have been shown as Rs. 25 lakhs. From the information supplied already, the rates given to Bharat Sewak Samaj seem to be the same as given to other contractors. Can details be supplied for such savings ?

15. In case of the Left Bank Canal, lining has been provided for a depth of 5 feet and length of 36 miles. It is not quite clear on what consideration this 5 feet depth only has been provided. The discharge that will be required for the ayacut in the first stage cannot be passed with this depth of 5 feet. If the water level goes above 5 feet, is the lining not likely to be undermined ?

16. The Right Bank Canal is not proposed to be lined in the final stage. Will the lining work not be difficult and cost more later on ? Would it not be advisable to line both the canals for the discharge required for the proposed ayacut in the first stage and reduce the length of the main canals so as to be within the estimated amounts ? The design principles for both lined and unlined canals from economic considerations are quite different. If a canal is to be lined eventually, its economic design would not be the same, if it is to run as an unlined canal in the first phase. It appears that the lining of canals was dropped without consideration of the corresponding changes that would be necessitated which are being considered during course of execution. It is doubtful if the Left Bank Canal, which is partially lined for a depth of 5 feet only and which is narrow and deep, can function efficiently.

GENERAL

The estimate for both the canals will materially change on account of the changes that have been made in the design. It would, therefore, seem to be necessary to prepare fresh estimates immediately for the designs that are being adopted and also the rates that are being obtained and then compare the overall excesses. More or less there seems to be no project estimate on the basis of which the work is being executed. It is for consideration of the Project Authorities if canals should not be lined in the first instance and less length of the canals done in the first phase.

APPENDIX XIII (*contd.*)

Copy of letter No. 24373 CI/58-1, dated 14th February, 1959 from the Chife Engineer, Nagarjunasagar Canals, Hyderabad to the Secretary, Nagarjunasagar Control Board, Hyderabad.

SUBJECT: *Nagarjunasagar Canals—Savings and excess on estimates.*

Reference : *D.O. Lr. No. COPP/I&P/NS/41/407, dated 15th January, 1959 by Shri M. P. Mathrani, ISE (Retd.) Member, Irrigation & Power Team addressed to the Administrator, Nagarjunasagar Control Board.*

With reference to the above D.O., I furnish herewith a note containing my replies to the various comments para by para for scrutiny and transmission to Mr. Mathrani.

NOTE

DESIGN OF CANALS

Para 2 : (Sections).

The changes in the design of the canal sections from what has been given in the project estimate are necessitated due to local conditions and soil particulars observed from detailed investigations and examining several alternatives. The design adopted has been finalised for the two canals for the most economical construction considering (*i*) alignment, (*ii*) soil cover and incidence of rock (*iii*) obligatory crossings of ridges and valleys. In the case of Right Bank Canal the depth of the soil cover in the first reach varies from 3′ to 5′ below ground and below this rock is met with. In view of this a wider and shallower section, *i.e.*, 250′ × 15′ has been proposed as it is cheaper than the narrower section of 155′ × 20′ (adopted in the Project proposals, due to saving effected in the excavation of rock. The estimates sanctioned so far and the quantities of earthwork worked out for the balance of the reach now finalised portend, that the total quantity of earthwork will not vary by more than ten per cent. In the Left Bank Canal the total quantities, based on estimate, already sanctioned result in savings in the quantities for earthwork. This was discussed with Shri Mathrani on the 9th and 10th when the total quantities of earthwork in respect of Right Bank Canals, and the quantities of earthwork as per sanctioned estimates compared with the corresponding provision in the phase estimate in the case of Left Bank Canal, were perused by him. A narrower section adopted for the Left Bank Canal has resulted in the reduction of the quantities under lining.

Para 3 : Estimates for only two major crossings, *viz.*, Chandravanka Aqueduct on the Right Bank Canal and Halia Aqueduct on the Left Bank Canal are so far sanctioned. A comparative study of the costs with a trough section corresponding to the normal canal sections of 155′ × 20′ and 250′ × 15′ (for Right Bank Canal) revealed,

that there is no material difference in the costs. As already mentioned elsewhere an additional provision of Rs. 45 lakhs is made under cross drainages during the latest review of the project estimate.

Para 4 : There are project estimates for both the canals. The reasons for the changes made in the working proposals have been explained in para 1.

Para 5 : The reduction (from 83 lakhs to 64.6 lakhs) figured in the cost of cement and steel etc., is due to the rebate anticipated in the rate of cement to be applicable to Nagarjunasagar Project for payment to the State Trading Corporation.

Para 6 : In the first and second reviews of the project estimates an excess of 200 lakhs was anticipated on account of increased cost of earthwork on both the canals. This assessment was based primarily on the proportion of rock so far met with. In the head reaches of the canals, there are a number of deep cuttings in the hilly terrain and rock cutting is heavy. This excess is not likely to occur as the incidence of rock in the lower reaches is expected to be comparatively less, since the canal comes out of the hills into the plains. The correct position can be known after the detailed estimates for the two canals for the entire length are framed. Special staff is working on the field now for this purpose.

Para 7 : The saving and excees of Rs. 75 lakhs for Right Bank Canal tunnel are not shown in the latest review as they balance each other.

The cost of the Left Bank Canal tunnel as per the finalised proposals for a tunnel length of 7,500 feet for a carrying capacity of 15,000 cusecs, works out to Rs. 227 lakhs at the rates of settled contract. This is within the provision of 289.70 lakhs made in the phase estimate for a tunnel 15,300 feet long and 11,000 cusecs carrying capacity.

The joint report of 1954 provides for one set of twin tunnels at the head and a second tunnel of single bore, in the second phase reach, for the Left Bank Canal. In the phase estimate of 1956 provision is retained only for the cost of one set of twin tunnels at the head. The amount of Rs. 1,39,55,300 represents the cost of one tube and thus the cost of the twin tubes will be twice. The method of working out the cost is in order. There is a misprint in the rate per unit of enlargement. The quantity under enlargement is 8,323,20 units and its cost is estimated at Rs. 810.00 per unit (1,000 Cft.).

Para 8 : This has been clarified during the discussions held on 9th and 10th February, 1959 (*Vide* record of discussions) and also this office Lr. No. 24373 CI/58-37, dated 11th February, 1959.

Para 9 : The actual cost of land compensation cannot be assessed correctly until the alignment is laid on the ground and prevaluation statements are ready. The excess of Rs. 15.00 lakhs is assessed

for land compensation in the Left Main Canal on the basis of acquisition made in the First Reach. In the case of distributaries, investigations are in the preliminary stage and it is too early to guage if there will be any excess over the L.B. provision of Rs. 20 lakhs made in the phase estimate for land acquisition under distributaries.

Para 10 : In the latest review of the project estimate a sum of Rs. 45 lakhs has been provided to cover the probable excess in the cost of C.D. Works for both the canals as already mentioned in para 3 above.

Para 11 : The savings of Rs. 30 lakhs due to procurement of surplus machinery are reckoned against the provision in the canal estimates for (A) gross expenditure; purchases of special tools and plant but not against the net provision.

A consolidated estimate for Q. Special Tools and Plant for the Right Bank Canal is included in the phase estimate.

The procurement of machinery for the two canals is planned, keeping in view the work load on hand and the equipment available. An exhaustive review on the problem of Spl. T. & P. is furnished in a separate note in reply to Mr. Mathrani's letter No. COPP/I&P/MP/NS-45, dated 17th January, 1959 addressed to Adminsitrator, Nagarjunasagar Project.

Para 12 : Cost per acre of distributary system provided in the phase estimate is Rs. 50. An excess of Rs. 5 lakhs has, therefore, been made for the 10,000 acres at that rate.

Para 14 : Savings anticipated in the case of public participation and departmental work is assessed to be Rs. 20 lakhs ultimately, as on the works let out to Labour Mukadams, labour cooperatives and those undertaken departmentally, the operation costs will be 5 to 10 per cent less than estimated rates. In this context the public participation need not be taken as Bharat Sevak Samaj alone.

Para 15 : This aspect has already been explained in para 2 above and in this office letter No. C/A, dated 2nd January, 1959.

Para 16 : Lining the canal is programmed to be done later on for carrying the ultimate discharge and as such there is no provision in the first phase estimate. It is expected that there will be no difficulty to line the canal later. Reduction in the length of canal means altering the scope of the project and its benefits. Lining can be done straightaway if sanction is accorded for the extra funds required for lining the canal.

APPENDIX XIV

Statement of Sanctioned Estimates of Nagarjunasagar Right Bank Canal

Statement of Nagarjunasagar Right Canal—Estimates sanctioned as on 9-2-1959 *and amount required for execution*

Sl. No.	Name of Work	Estimate amount in Rs.	Amount required for execution in Rs.* (Tendered amount & other L.S.)
1	2	3	4
	I. Excavation of N. S. Right Canal from Ch:		
1.	1329 —11758	1,13,18,000	1,00,00,000
2.	1055 —17045	1.13,92,000	1,13,92,000
3.	18403 —26708	1,36,70,191	1,14,60,000
4.	6/2 — 6/4	4,92,000	4,92,000
5.	6/4 — 7/4	20,17,000	20,17,000
6.	7/4 — 8/4	15,21,000	15,21,000
7.	8/4 — 9/0	3,20,000	3,20,000
8.	9/0 — 10/0	24,65,000	24,65,000
9.	10/0 — 11/0	13,89,000	13,89,000
10.	11/0 — 12/0	12,01,000	12,01,000
11.	12/0 — 13/0	16,33,000	16,33,000
12.	13/0 — 14/0	8,20,000	8,20,000
13.	14/0 — 15/0	6,72,000	6,72,000
14.	15/0 — 16/0	4,93,000	4,93,000
15.	16/0 — 17/0	5,45,000	5,45,000
	Forming Buggavagu Dam from Ch:		
16.	17/0 — 21/0	1,19,24,000	1,19,24,000
	Excavation of N. S. Right Canal		
17.	20/7+24 — 21/5	6,81,000	6,79,258
18.	21/5 — 22/3	11,09,000	11,09,450
19.	22/3 — 23/0	7,94,000	8,31,000

*Work not yet taken up. Revised Estimate for Rs. 215·77 lakhs was submitted.

APPENDIX XIV (*concld.*)

1	2	3	4
	Excavation of N.S. Right Canal from Ch:		
20.	23/0 — 24/0	6,25,000	6,51,500
21.	24/0 — 25/0	7,34,800	7,34,800
22.	25/0 — 26/0	5,10,000	5,20,403
23.	26/0 — 27/0	10,95,000	10,95,000
24.	27/0 — 28/0	12,32,000	12,09,440
25.	28/0 — 29/0	9,61,300	8,51,912
26.	29/0 — 30/0	7,78,500	7,32,657
27.	30/0 — 31/0	12,64,200	10,77,000
28.	31/0 — 32/0	9,71,900	9,62,900
29.	32/0 — 33/0	8,76,000	8,22,300
30.	37/0 — 38/0	9,97,000	9,39,600
31.	38/0 — 39/0	9,87,000	9,81,730
32.	39/0 — 40/0	8,29,000	7,62,500
33.	40/0 — 41/0	9,17,000	8,46,103
34.	41/0 — 42/0	9,26,000	8,53,580
35.	42/0 — 43/0	9,42,000	8,85,628
36.	44/0 — 45/0	9,33,000	9,10,000
	TOTAL ..	8,00,45,341	7,57,32,789
	II.F. Cross Drainage Works		
1.	Construction of U.T. @M.s/5+120	2,08,000	2,03,027
2.	Construction of Aqueduct @ 11/1+590 (Chandravanka)	29,04,000	27,93,000
	TOTAL ..	31,12,000	29,96,027
	III.G.Bridges		
1.	Construction of A"Class Bridge@ 6/5+220 ..	1,95,000	1,95,000
2.	Do. @ 14/3+335 ..	1,62,000	1,60,828
		3,57,000	3,55,828
	Abstract		
I.	L. Earthwork	8,00,45,341	7,57,32,789
II.	F. Cross Drainage Works	31,12,000	29,96,027
III.	G. Bridges	3,57,000	3,55,828
	Grand Total	8,35,14,341	7,90,84,644

Sd/-P.V. Koteswara Rao,
P.A. to S.E. Rt. Canal Circle

Sd/-Chief Engineer, PWD.,
Nagarjunasagar,
Right Canal

APPENDIX XV

STATEMENT OF SANCTIONED ESTIMATES OF NAGARJUNASAGAR LEFT BANK CANAL

Statement of Nagarjunasagar Left Canal Estimates sanctioned upto 1/1959 and amount required for execution

Sl. No.	Name of Work	Estimated Amt., in Rs.	Remarks
1	2	3	4
	I. *Excavation of N.S. Left Canal from Ch:*		
1.	0·0 to 15·5	24,600	
2.	15·5 — 17·5	46,600	
3.	17·5 — 18·5	28,100	
4.	18·5 — 19·5	26,000	
5.	19·5 — 20·5	27,800	
6.	20·5 — 21·5	32,300	
7.	21·5 — 23·0	43,400	
8.	25·0 — 26·5	46,500	
9.	26·5 — 27·5	31,000	
10.	27·5 — 28·5	40,000	
11.	28·5 — 29·5	44,900	
12.	29·5 — 30·5	52,000	
13.	30·5 — 32·5	82,000	
14.	32·5 — 33·5	59,000	
15.	33·5 — 35·5	82,000	
16.	35·5 — 36·5	43,000	
17.	36·5 — 37·5	51,000	
18.	37·5 — 39·5	82,940	
19.	39·5 — 40·5	47,620	
20.	40·5 — 41·5	59,700	
21.	41·5 — 42·5	56,300	
22.	42·5 — 43·5	60,570	
23.	43·5 — 44·5 ..	62,400	

APPENDIX XV (*contd.*)

1	2			3	4
	From Ch:				
24.		44·5	— 45·5	66,900	
25.		45·5	— 46·5	68,200	
26.		46·5	— 47·5	69,200	
27.		47·5	— 48·5	72,000	
28.		48·5	— 49·5	72,400	
29.		49·5	— 50·5	69,600	
30.		50·5	— 51·5	80,300	
31.		51·5	— 52·5	81,800	
32.		52·5	— 53·5	79,200	
33.		53·50	— 54·5	82,400	
34.		54·50	— 55·5	86,600	
35.		55·5	— 56·5	90,300	
36.		56·5	— 57·0	50,200	
37.		57·0	— 57·5	50,300	
38.		57·5	— 58·0	51,200	
39.		58·0	— 58·5	49,330	
40.	App. ramp & transition	63·15	— 79·0		
41.	Tunnel	79	—154	2,63,02,000	
42.	Exit ramp & transition	154	—169		
43.	Exit ramp	171	—184·5	14,22,000	
44.	Exit cut	187·5	—197·5	33,99,000	
	Excavation in mile				
46.		6 (II Half)	.. .. ..	11,56,600	
47.		7	.. .. ..	7,10,000	
48.		8	.. .. ..	9,08,000	
49.		9	.. .. ..	8,61,000	
50.		10	.. .. ..	8,69,000	
51.		11	.. .. ..	9,35,000	
52.		12	.. .. ..	12,86,000	

APPENDIX XV (*concld.*)

1	2	3	4
	Excavation in mile		
53.	13	10,36,000	
54.	14	11,88,000	
55.	15	5,50,000	
56.	16	6,70,000	
57.	19 (II half)	4,93,000	
58.	20	7,79,000	
59.	21	8,24,000	
60.	22	9,37,000	
61.	23	10,56,000	
62.	24	9,60,000	
63.	25	13,40,000	
64.	26	9,92,529	
65.	29	8,88,931	
66.	30	8,42,000	
67.	31	11,30,877	
68.	32	14,81,118	
69.	33	6,72,480	
70.	34	8,70,910	
71.	35	9,11,534	
	I. Total for L-Earth Work	5,77,21,639	
	II. F. *Cross Drainage Works*		
72.	Diversion of Chilkurthi Stream	94,000	
73.	Hallia aqueduct	44,00,000	
74.	Improvements to Alwal Tank	30,000	
		45,24,000	
	GRAND TOTAL	6,22,45,639	No savings are anticipated as a result of tenders.

Sd/-*Chief Engineer, P.W.D.*
Nagarjunasagar Left Bank Canal Unit
16-2-59

APPENDIX XVI

COMMENTS OF C.W. & P.C.

M. HAYATH
Chairman.

D.O. No. CHN/N-4.
GOVERNMENT OF INDIA
CENTRAL WATER & POWER COMMISSION
BIKANER HOUSE.
New Delhi-2, the 9th August, 1960.

My dear Shri Borker,

Please refer to your D.O. letter No. COPP/I&P/7/59/1372, dated 8th August, 1960. I have to state that I have no comments to offer on the Nagarjunasagar Report.

Yours sincerely,
M. HAYATH.

Shri D. S. Borker,
Secretary, Consultative Committee,
Irrigation & Power Projects,
Yojana Bhavan, NEW DELHI.

L2COPP(PC)60—16-8-60—1,500—Sec. II—GIPF.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